AN ECONOMIC EVALUATION OF THE EFFECTIVENESS OF THE TEXAS PECAN CHECKOFF PROGRAM

A Thesis

by

ELI DEL MOORE

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

May 2008

Major Subject: Agricultural Economics

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Approved by:

Chair of Committee,	Gary Williams
Committee Members,	Oral Capps, Jr.
	Leonardo Lombardini
	Marco Palma
Head of Department,	John Nichols

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ABSTRACT

An Economic Evaluation of the Effectiveness of the

Texas Pecan Checkoff Program. (May 2008)

Eli Del Moore, B.S., West Texas A&M University

Chair of Advisory Committee: Dr. Gary Williams

The Texas Pecan Board was established in 1998 to administer the Texas Pecan Checkoff Program and is financed through a one-half cent per pound assessment on grower pecan sales. The Board spends the assessment collections on a variety of advertising campaigns in an attempt to expand demand for Texas pecans, both improved and native varieties, and increase the welfare of Texas pecan growers. This study presents an evaluation of the economic effectiveness of the Texas Pecan Checkoff Program in expanding sales of Texas pecans.

First, the effects of Texas Pecan Board promotion on sales of all Texas pecans are determined using the ordinary least squares estimator (OLS) followed by a test for differential effects of Texas Pecan Board promotion on sales of improved and native Texas pecan varieties using the seemingly unrelated regression. The analysis indicates that the Texas Pecan Checkoff Program has effectively increased sales of improved varieties of Texas pecans, but has had no impact on sales of native varieties of Texas pecans. A benefit-cost analysis determines that the additional sales revenues generated is relatively large compared to the dollar value spent on promotion indicating that the Texas pecan promotion program has been financially successful.

To my dear, my love, my Laura Ann

ACKNOWLEDGEMENTS

I owe all that I've accomplished to the grace and mercy of my Lord and Savior, Jesus Christ.

I owe many thanks to all the individuals who helped in the completion of this thesis. First of all, I would like to thank the chair of my committee, Dr. Gary Williams, for his advice, wealth of knowledge, encouragement, and dedication to this thesis as well as my overall education. I would also like to thank the members of my committee, Dr. Oral Capps, Dr. Leonardo Lombardini, and Dr. Marco Palma for contributing to my understanding of econometrics, economics, and the pecan. I also send my gratitude to Dr. James Woodyard, Dr. Joshua Lewer, Dr. George Davis, and Dr. Frank Landram for their inspiration, words of wisdom, and humor.

My thanks are also extended to Mike Adams, the Texas Pecan Board, and pecan producers for their input, comments, and funding. In addition, I'd like to thank Cindy Wise and the Texas Pecan Growers Association for their contribution of data and input on the Texas Pecan Board.

I would like to thank my family for their support throughout my education. I'd like to thank my fiancée, Laura, for her love, support, sacrifice, and encouragement. I'd like to thank Mom and Dad for their phone calls, emails, support, and always reminding me of the importance of education. Finally, I'd like to thank my siblings, Eppie, Ethan, Eran, and Eben for being my best friends.

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CHAPTER I

INTRODUCTION

The Texas Pecan Board (TPB) was established under the Texas Commodity Referendum Law (Texas Agricultural Code Chapter 41) in August of 1998 to administer the Texas Pecan Checkoff Program. The law authorizes the Board to promote pecans in an attempt to increase the welfare of Texas pecan growers. The Board's programs are financed through a one-half cent per pound assessment on pecan sales from growers to first handlers.

In the Texas Pecan Checkoff Program, growers who have 500 pecan trees or more and at least 15 acres are required to pay the assessment and are referred to as "qualified growers." All qualified growers are required to pay the checkoff assessment of one-half cent per pound of pecans sold or transferred to a processor or pool. The first party to purchase the pecans from the grower is referred to as the first handler and includes shellers, brokers, processors, accumulators, and growers who market their own pecans. The assessment is due when the pecans are first processed or shelled. At that point, the first handler is required to report and submit the assessment. Because the checkoff program is a mandatory program, the first handler is required by law to collect the assessment from the grower and then report and submit it to the Texas Pecan Board. However, there is little to no enforcement of the mandatory checkoff collection due to a lack of funds and manpower at the Texas Department of Agriculture. Consequently,

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This thesis follows the style of the *American Journal of Agricultural Economics*.

only about 44% of the available funds are collected on average each year which effectively limits the potential impact of the Texas Pecan Checkoff program and suggests that there may be a free rider problem (Adams 2007).

Purpose and Objectives

The purpose of the research reported in this thesis is to evaluate the effectiveness of the Texas Pecan Checkoff Program in shifting the demand for Texas pecans. The specific objectives of this research are:

- Qualitatively analyze the U.S. and Texas pecan industries and the role of the Texas Pecan Checkoff Program as background to the statistical analysis of the program
- Identify and statistically measure the effects of the main economic drivers of all Texas pecan sales compared to those of improved and native Texas pecan sales;
- Statistically isolate the effects of the promotion of Texas pecan sales through the Texas Pecan Checkoff Program, and
- Determine the return on the investment made on promotion of all Texas pecan sales as well as improved and native Texas pecans through the Texas Pecan Checkoff Program.

The first objective is achieved in Chapter II with a detailed examination of the economic structure of the U.S. and Texas pecan industries. Of particular interest in that analysis is the role of the Texas Pecan Board and the pecan promotion program expenditures made by the Board since the inception of the Texas Pecan Checkoff Program in 1998. The qualitative analysis in that chapter will form the basis for the conceptual model developed in Chapter III regarding economic drivers of Texas pecan sales and the related hypotheses that will be tested.

The second and third objectives will be achieved in Chapters III and IV with the development of a conceptual model of Texas pecan sales and the econometric testing of the hypotheses suggested by that model. The parameters of the model for all Texas pecans will be estimated using the ordinary least squares (OLS) estimator to test for statistical significance between the hypothesized economic drivers, including Texas Pecan Board promotion expenditures and sales of Texas pecans. The seemingly unrelated (SUR) estimator will be used to test for different promotion effects on the sales of improved versus native pecans. The final objective will be accomplished in Chapter IV by using the econometric results from Chapter III to calculate a benefit-cost ratio (BCR) related to the Texas Pecan Board pecan promotion program expenditures.

Literature Review

The United States produces more than 80% of the world's supply of pecans (Onunkwo and Epperson 2000). Because of the high proportion of U.S. pecans that are exported the majority of past research on pecan promotion has focused on export demand expansion rather than domestic demand expansion. Regardless, the available literature provides a firm foundation and background on the pecan industry, as well as insights on the promotion of pecans that will be useful for this study of domestic pecan promotion. This section critically reviews the literature relevant to the evaluation of pecan promotion programs as well as related research.

Pecan Promotion Evaluation

Onunkwo and Epperson (2000) analyzed U.S. pecan export demand promotion. Although Onunkwo and Epperson did not analyze state-level or even domestic U.S. promotion of pecans, they provided valuable information and examples relevant to an analysis of domestic pecan promotion. The export promotion programs they discuss are the Foreign Market Development Program and Targeted Export Assistance promotion program which spend approximately \$30.5 and \$98 million per year on average in export promotion. Onunkwo and Epperson (2000) postulated that the export demand for U.S. pecans was a function of income, U.S. promotion expenditures for pecans as well as walnuts and almonds, and prices of pecans, almonds, and walnuts. The prices of almonds and walnuts were included in their study to account for the existence of complement/substitute relationships. Onunkwo and Epperson concluded that pecan promotion expenditures were statistically significant at the 0.01 level of significance in expanding demand for pecans in export markets. They calculated that the benefit-cost ratios for federal export promotion were 6.45 and 6.75 for Asia and the Europe Union, respectively (Onunkwo and Epperson 2000). They also calculated promotion elasticities for Asia and the European Union as 0.98 and 0.06, respectively.

Although Onunkwo and Epperson (2000) evaluated the effectiveness of pecan export promotion to Asia and the European Union, their study did not specifically analyze Texas pecan promotion. However, the study provides some insight on the variables affecting pecan sales, such as the prices of almonds and walnuts, and one method for calculating the benefit-cost ratio for investments in pecan promotion.

According to Wood, Payne, and Grauke (1994), the pecan industry experienced considerable growth during the twentieth century that could have continued if the industry had not failed to develop and expand markets. Florkowski and Park (2001) discussed strategies for demand expansion including advertising and marketing campaigns. They concluded that demand expansion programs can have a statistically significant, positive effect on consumption when the promotion targets pecan uses, pecan visibility, and the health benefits of pecans such as its effect on decreasing LDL cholesterol levels (Rajaram et al. 2001). These three factors have been the primary targets of Texas Pecan Board promotion expenditures, specifically pecan visibility.

Related Research

According to Florkowski, Purcell, and Hubbard (1992), promotion programs for other tree nuts have decreased the market share of pecans and have adversely affected the pecan market. Consequently, the success of other tree nut promotion programs suggests that pecan promotion programs may be an important factor affecting the demand for pecans. Because pecans are a perennial crop, prior research on perennial crop checkoff programs may provide some insights for this study.

There has been more research reported on almond promotion programs, primarily for California almonds, than on pecan promotion programs. Because almonds are arguably the closest substitute to pecans, research on almond promotion provides insight into techniques that can be used to evaluate the Texas Pecan Checkoff Program. Crespi and Sexton (2001) analyzed the economic impacts of promotion expenditures by the Almond Board of California on the U.S. demand for almonds over the crop years of 1962/63 through 1997/98. They report a benefit-cost ratio for that program of between 1.53 and 7.60 (95% confidence interval) assuming a supply elasticity of 1.50. Although their analysis is national in scope, it provides some insights on the type of model that could be used to evaluate the Texas checkoff program. Crespi and Sexton (2001), following previous research conducted by Bushnell and King (1986) and Alston et al. (1995), estimated the U.S. per capita demand for pecans as a function of the deflated farm price of almonds, deflated consumer income, and deflated annual expenditures on almond promotion. However, they did not include promotion expenditures of other nuts as an independent regressor. Crespi and Sexton (2000) indicated that the benefit-cost ratio was dependent upon the elasticity of supply. Thus, it is possible to specify upper and lower bounds for the elasticity of supply and develop confidence intervals in order to attach a probability to the benefit-cost ratio (Altston et al. 1997).

Davis (2005) argued that the statistical significance of a promotion program as a demand shifter may not fully explain the impact of a promotion program on increases or decreases in producer revenue ability. For example, if supply is inelastic, a relatively small change in demand (small budget program) can have a drastic effect on price. However, for a small promotion program at the state level, promotion-induced shifts in demand may have little effect on the market price, and producer revenues will increase through increased consumption at a constant price, ceteris paribus.

Williams and Capps (2006) demonstrated an alternative method of measuring the return to producer investment in promotion through a commodity checkoff program using the internal rate of return (IRR). Williams, Capps, and Bessler (2004) calculated an IRR of 14.4% for the Florida orange juice promotion program meaning that all the promotion expenditures would have had to have been placed into an investment earning more than 14.4% annually to outweigh the benefits of the promotion program.

Halliburton and Henneberry (1995) evaluated the effectiveness of U.S. export promotion programs (the Foreign Market Development Program and the Market Promotion Program) with application to almonds. Their study is similar to the Onunkwo and Epperson study except that they considered almond exports rather than pecan exports. In their model, Halliburton and Henneberry initially included trend as an independent variable, but ultimately dropped it from the model because the results improved without it. Furthermore, they lagged promotion expenditures to account for the delayed consumer response. An SUR was not used in the Halliburton and Henneberry (1995) study because the SUR required more observations than were available. Halliburton and Henneberry (1995) estimated the almond model in three different forms: Cobb-Douglas, linear, and exponential. Although this study provides useful insight into model specification and analysis of a promotion program, neither the techniques used nor conclusions reached were strictly applicable to Texas pecans.

Williams, Capps, and Palma (2007) evaluated the effectiveness of Marketing Order 906 in promoting Texas grapefruit and orange sales. They discussed that more precise estimates could be achieved using SUR rather than OLS because correlation in the disturbance terms are considered when using the SUR. They utilized the polynomial distributed lag (PDL) procedure to take into account the carryover effects of the promotion expenditures. They found that even though the increase in shipments achieved by the program may not change from one period to the next, the BCR can vary quite widely because the price of the promoted product varies from period to period. Consequently, they defined an alternative BCR which they call the "shipments BCR" calculated as the change in shipments of citrus per dollar expended on promotion. Their discussion of the BCR demonstrated that even if a promotion program is found to be statistically significant in its effects on demand, the revenues generated by the increased demand may not outweigh the cost of promotion. The Williams, Capps, and Palma (2007) study provides important insights regarding promotion evaluation data, benefit-cost analyses, and appropriate analytical methodology.

Organization of Remaining Chapters

The remainder of this thesis is organized as follows. Chapter II will provide a background analysis of the U.S. and Texas pecan industries with a focus on the pecan promotion program administered by the Texas Pecan Board. Chapter III will propose and discuss the methodology, the conceptual models, data, and other relevant conceptual issues. Chapter IV will provide and discuss the models and associated econometric results, as well as the calculated benefit-cost ratios. Chapter V will include a summary and conclusions of the study and recommendations for future research.

CHAPTER II

THE PECAN INDUSTRY

The pecan [*Carya illinoinensis* (Wangenh.) C. Koch] industry is unique, functioning in a market relatively free of government intervention, and supplying a perishable, perennial commodity with a natural tendency for yields to fluctuate widely from year to year. The alternate bearing nature of the pecan tends to create a pattern of high production in one year followed by low production in the next, often referred to as the "on" and "off" years, respectively.

There are hundreds of pecan varieties throughout the world, classified as either native or improved varieties (Thompson and Young 1985). Trees that have not been grafted or budded are referred to as native or seedling. On the other hand, improved varieties are those that have been genetically altered through selection and controlled crossing in order to yield desirable characteristics such as high kernel percentage (high meat content), low yield variations, and resistance to diseases and insects (Worley 1994).

Like most prices, the price of pecans is determined by the forces of supply and demand. Consequently, low supplies in the off years often result in higher prices than in the on years. Pecans cannot be stored without refrigeration for long periods of time in anticipation of future prices due to their susceptibility to oxidation (Florkowski and Xi-Ling 1990). Moreover, pecan growers cannot easily substitute production resources to produce alternative crops. Consequently, pecan prices are sensitive to changes in supply and demand each season (Shafer 1996).

Background on the Pecan Industry

There are many forces affecting the sales of pecans each year, among the most important of which is the price of pecans (Onunkwo and Epperson 2000). Onunkwo and Epperson (2000) calculate price elasticities of demand for Asia and the European Union as -0.72 and -0.73, respectively. Because the pecan market is relatively free of government intervention, the price of pecans is determined primarily by the forces of supply and demand. The pecan industry markets two types of pecans: improved cultivars, and native or seedling varieties. Improved varieties tend to sell at a premium to native varieties (Figure 2.1). Understanding the causes of differentiation in prices received by growers for improved and native varieties is essential to understanding the hypotheses outlined in Chapter III.

Quality tends to be a major factor in the differentiation of prices of pecans as discussed by Florkowski and Park (1999). According to Wood, Payne, and Grauke (1994), quality has been one of the major factors in the growth of the pecan market. The quality of pecans is a function of certain physical characteristics. However, different segments of the industry emphasize different characteristics (Erickson 1994). Erickson (1994) concluded that the characteristics of pecans that are often associated with quality are meat yield, color, size, minimal foreign material, and shell-out ratio (meat to shell weight ratio). However, the shell-out ratio, calculated as the weight of the kernel or meat divided by the weight of the entire nut, has empirically proven to have the most significant impact on pecan prices (Florkowski and Hubbard 1994).

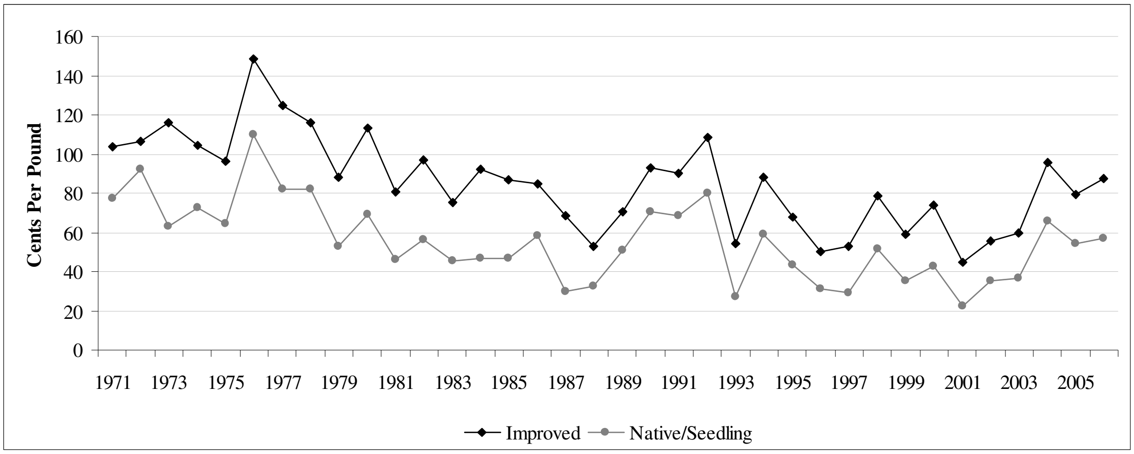

Figure 2.1: Real Prices Received by Texas Growers by Classification, 1971- 2006 (USDA 2006)

As a result of diminishing domestic supply, prices for high quality nuts have increased substantially (Santerre 1994). According to Tomek and Robinson (1972), differentiated nut quality across the market creates multiple prices for each quality which are determined by their own supply and demand functions. However, Okunade and Cochran (1991) found that different varieties of pecans tend to be of different qualities. Thus, they may be priced differently which is especially true for the improved varieties that are genetically designed for producing high quality nuts.

Nonetheless, Florkowski and Sarmiento (2005) found that quality impacts the differentiation of prices received by growers for different varieties of pecans and that the causes of quality differences in pecans may help explain aggregate changes in the prices of pecans. Florkowski and Sarmiento (2005) also found that growers who achieve higher yields also tend to achieve higher quality in their crop. Thus, because higher quality nuts sell for higher prices, growers with higher yields tend to receive higher prices. While quality differences in pecans primarily affect their relative prices and substitutability, quality problems caused by factors such as diseases, insects, or abiotic stresses (drought, hale, excessive rain, etc.) affect all varieties of pecans and impact the market availability of pecans.

Pecan Promotion Programs

The Pecan Promotion and Research Act of 1990 established a national pecan checkoff program that was implemented in 1992. A producer referendum on the continuation of the program in 1994 required by the Act failed and the program was terminated on March 15, 1994 (Sterns 1999). Since 1994, pecan promotion has primarily been through national export promotion programs operated by the Foreign Agriculture Service of the U.S. Department of Agriculture[1] or state-level checkoff programs. The National Pecan Shellers Association also promotes pecan sales through efforts to inform consumers about the variety of uses and health benefits of pecans. The International Tree Nut Council Nutrition Research and Education Foundation also operates a similar pecan promotion effort focused on the health benefits of tree nuts (including pecans) and educating consumers about nuts.

The U.S. Pecan Industry

Onunkwo and Epperson (2000) estimate that the United States produces more than 80% of the world's supply of pecans. The pecan is grown throughout the southern United States from California to Florida. Marketing and harvesting seasons vary widely

[1] Export promotion programs have included Foreign Market Development Program (FMDP), Market Access Program (MAP), Market Promotion Program (MPP) (Onunkwo and Epperson 2000)

throughout the United States (Figure 2.2). Texas harvests pecans earlier than anywhere in the country and has the longest marketing season. Arizona is the last to harvest its pecans. California has the shortest harvesting season. The top producing states include Georgia accounting for roughly 25% of annual utilized production, Texas (23%), and New Mexico (20%) (Figure 2.3). However, in 2005/2006, New Mexico was the leading producer accounting for 30.4% of utilized production (sales)[2]. That same year, Georgia accounted for 23.8% of U.S. utilized production and Texas followed with 21.8%. The value of U.S. pecan production has been growing steadily for the past thirty years with the improved varieties accounting for the majority of the growth (Figure 2.4).

The North American Free Trade Agreement (NAFTA) has expanded markets and increased competition in the U.S. pecan industry. Sun, Epperson, and Ames (1996), showed that although U.S. exports have been increasing, U.S. pecan imports from Mexico are larger that exports and have been increasing at a faster rate, leading to increasing U.S. net imports of pecans (Figure 2.5). They also argued that the U.S. pecan producer surplus has decreased by nearly 44% as a result of NAFTA. Eliminating barriers to U.S. imports of Mexican pecans as a result of NAFTA has increased the competition facing U.S. pecan producers. Even so, U.S. per capita consumption of pecans has remained relatively constant implying that imports are growing just fast enough to replace domestic production (Figure 2.6).

Competition among substitutable nuts is also increasing according to Florkowski and Park (2001). The pecan, almond, and walnut prices tend to follow similar patterns

[2] Utilized production is defined by the USDA as "the amount sold plus the quantities used at home or held in storage" (USDA 2006) and is considered equivalent to sales according to USDA definitions.

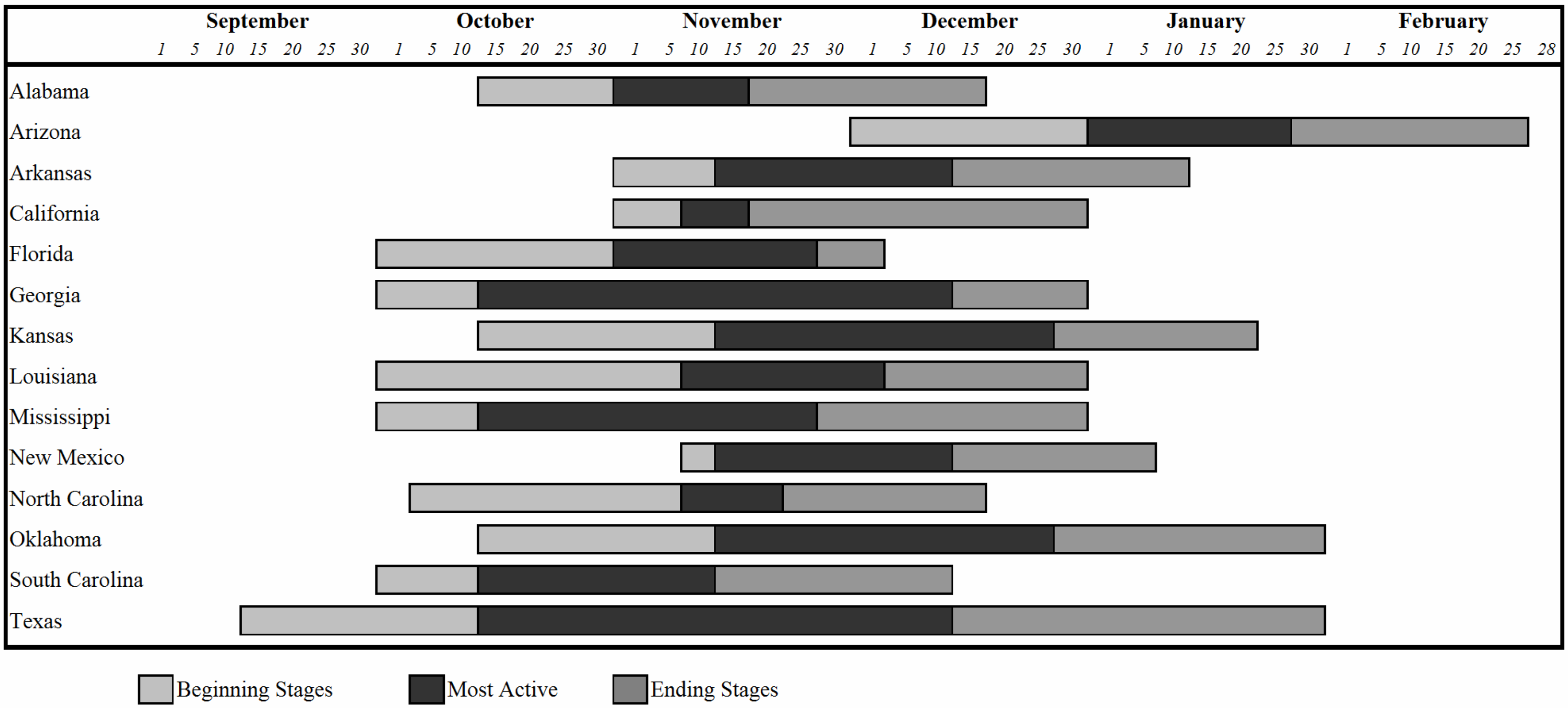

Figure 2.2: Harvesting Seasons by State (USDA 2006)

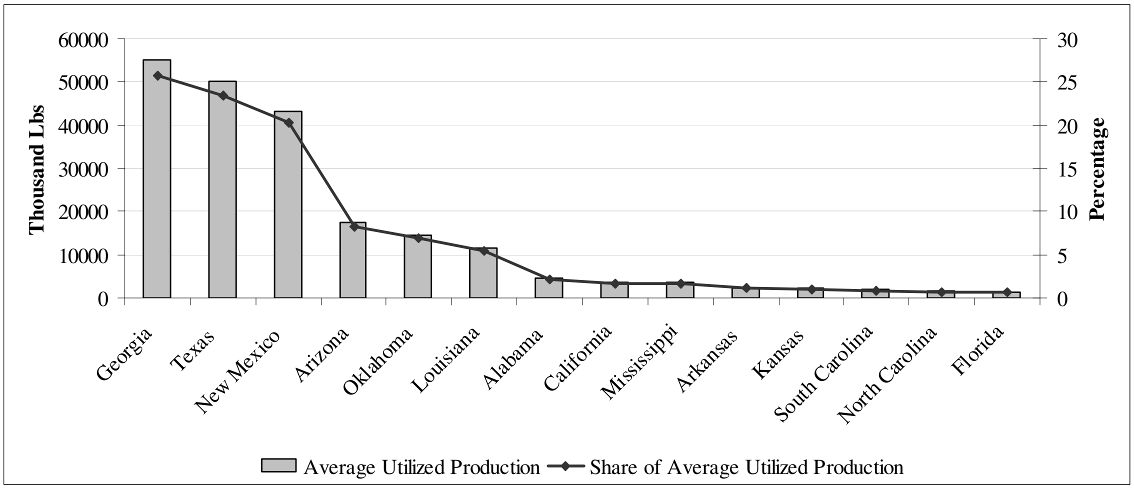

Figure 2.3: Average Utilized Production and Share of Utilized Production by State, 2002-2004 (USDA 2006)

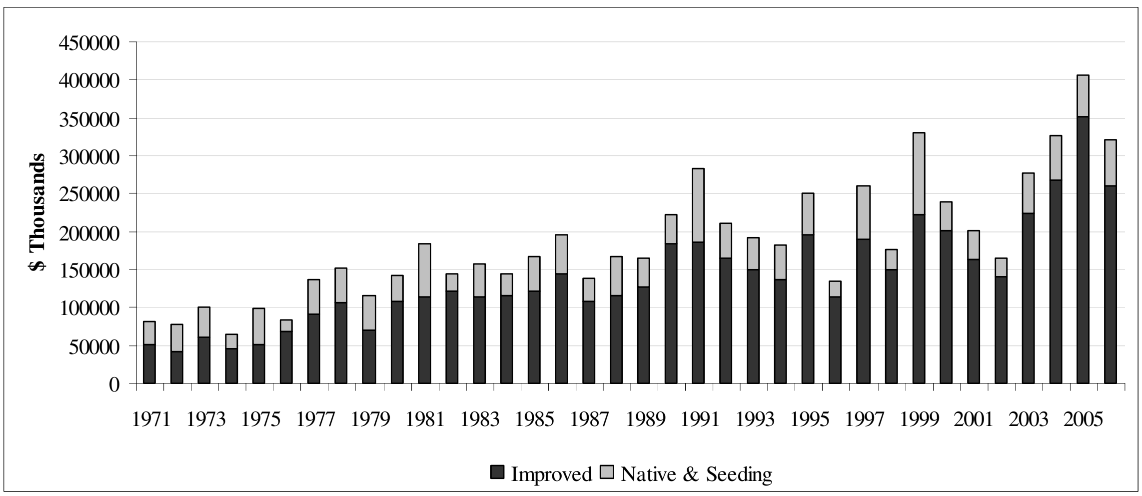

Figure 2.4: Value of U.S. Pecan Production by Variety, 1971-2006 (USDA 2006)

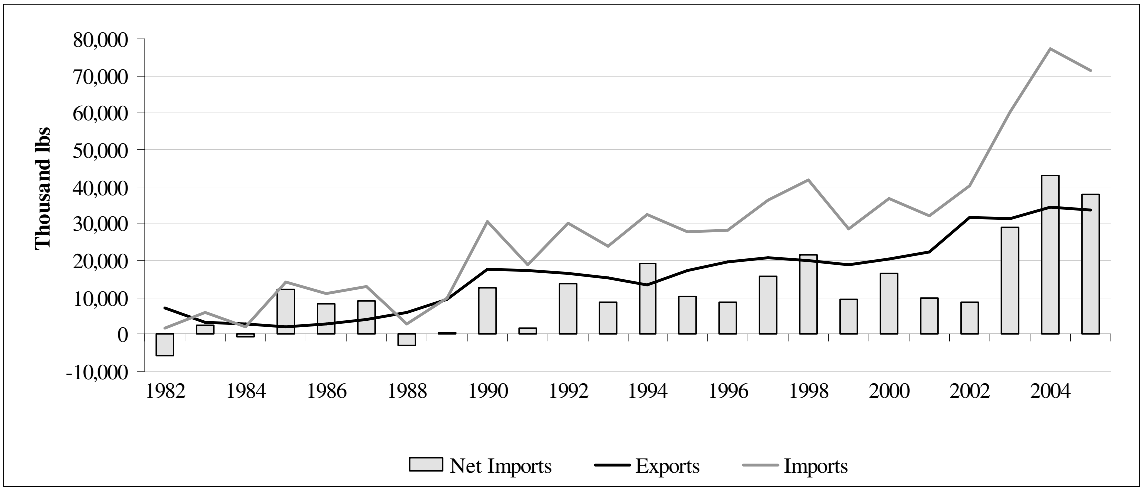

Figure 2.5: U.S. Pecan Imports, Exports, and Net Imports, 1982-2005 (USDA 2006)

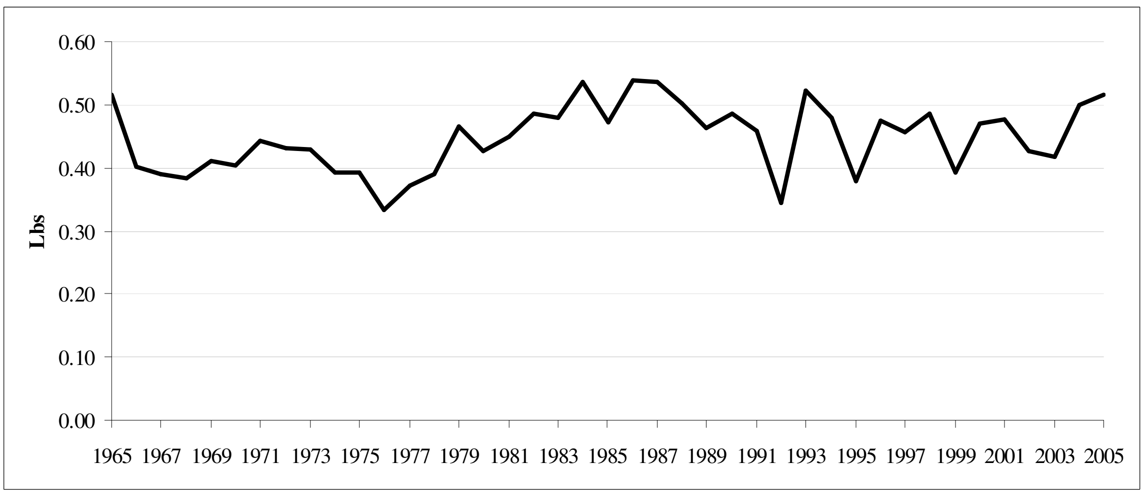

Figure 2.6: U.S. Per Capita Consumption of Pecans, 1965-2005 (USDA 2006)

as would be expected of highly substitutable products (Figure 2.7). Although almonds tend to be more expensive than pecans, the reverse has often been the case. Walnuts are almost always the cheapest of the three nuts.

The U.S. pecan industry has not experienced the same level of growth as the almond industry since the mid-1960s. Between 1965-1974 and 1996-2005, the marketable production of pecans increased 30% and total disappearance increased 52%. Over the same period, the marketable production of almonds experienced a 500% increase, while total almond disappearance increased by 250%. Santerre (1994) claimed that the rapid growth of almond production and disappearance was due to the success of aggressive promotion tactics to expand both domestic and foreign market demand.

The Texas Pecan Industry

Texas has been successful in producing pecans because of the numerous east Texas rivers that have provided transportation and irrigation for pecan growers (Wood, Payne, and Grauke, 1994). Although pecans are now grown statewide in Texas, the principal producing counties according to the USDA (2006) are Comanche, El Paso, and San Saba (Figure 2.8). The primary improved varieties grown in Texas are the Cheyenne, Desirable, Pawnee, Western, and Wichita (USDA 2006). The usual date of full bloom in Texas is during the month of April. Although harvest begins in mid-September and ends in late January, most of the harvesting activity takes place between mid-October and mid-December (see Figure 2.2).

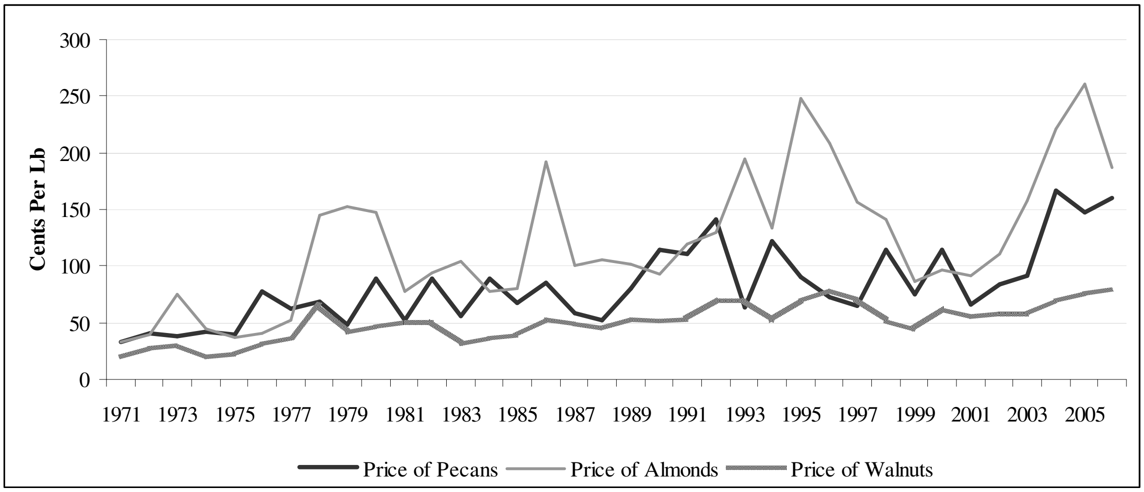

Figure 2.7: National Pecan, Walnut, and Almond Prices Received by Growers (USDA 2006)

The “on and off” year behavior of pecan yields which affects what is available for sale tend to be more apparent in native/seedling varieties than is the case for improved pecans. Because Texas produces an above average percentage of native/seedling varieties as seen in Figure 2.9, the occurrence of on and off years is more noticeable in the sales and production value of native/seedling pecans than is the case for improved pecans.

Producers of native varieties are more responsive to price, which also contributes to the observed volatility of native pecan sales (Adams et. al. 2007). When native prices are low due to quality or weather, producers may not even harvest their crop likely because they typically do not spend as much on inputs as do producers of improved pecans, and therefore, do not have as much overhead to cover. In some cases, the only costs they may need to recoup are harvesting expenses associated with actually harvesting the crop. This only adds to the problem of what is available for sale. On the

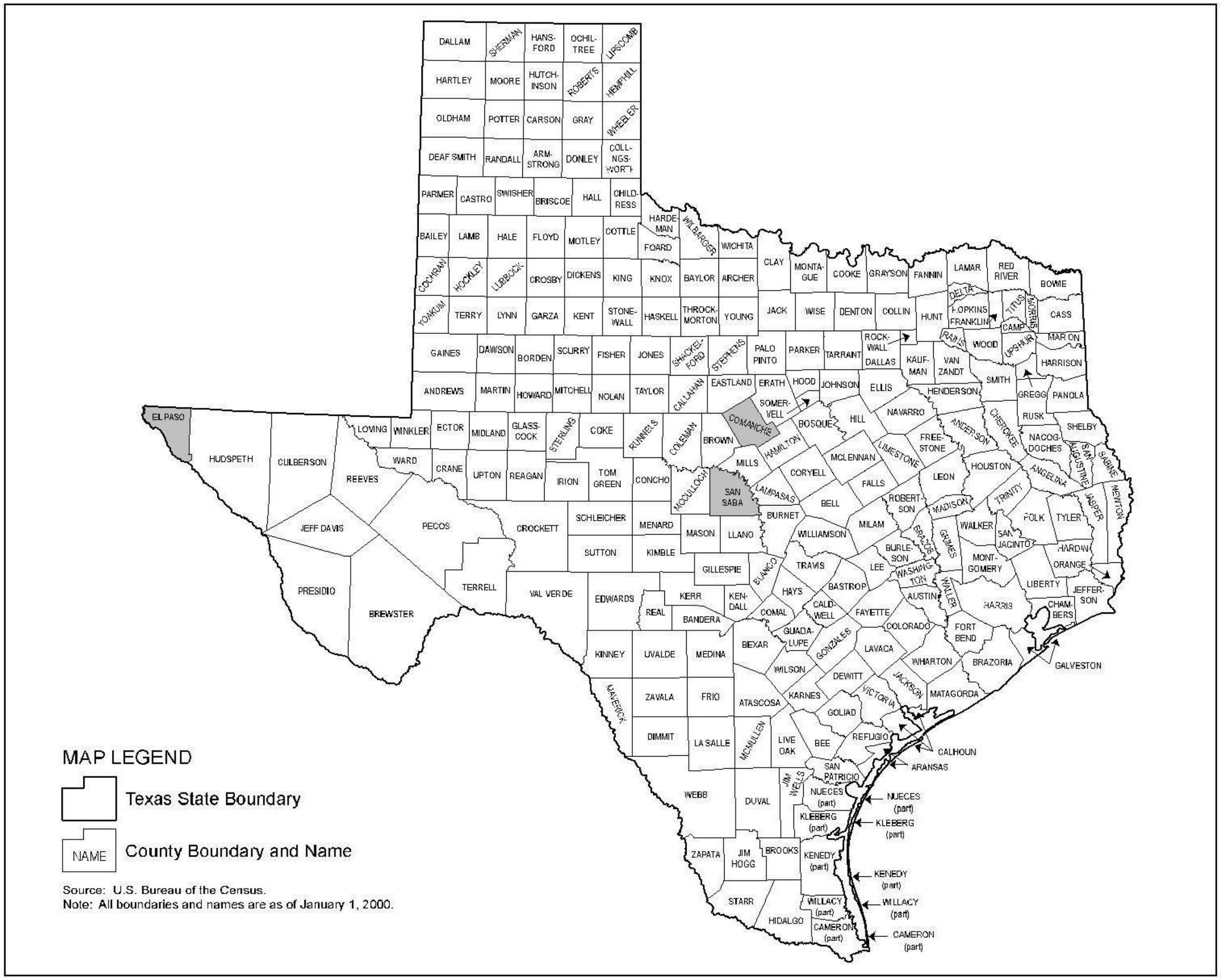

Figure 2.8: Primary Pecan Producing Counties in the State of Texas Shaded in Gray (U.S. Bureau of the Census 2000)

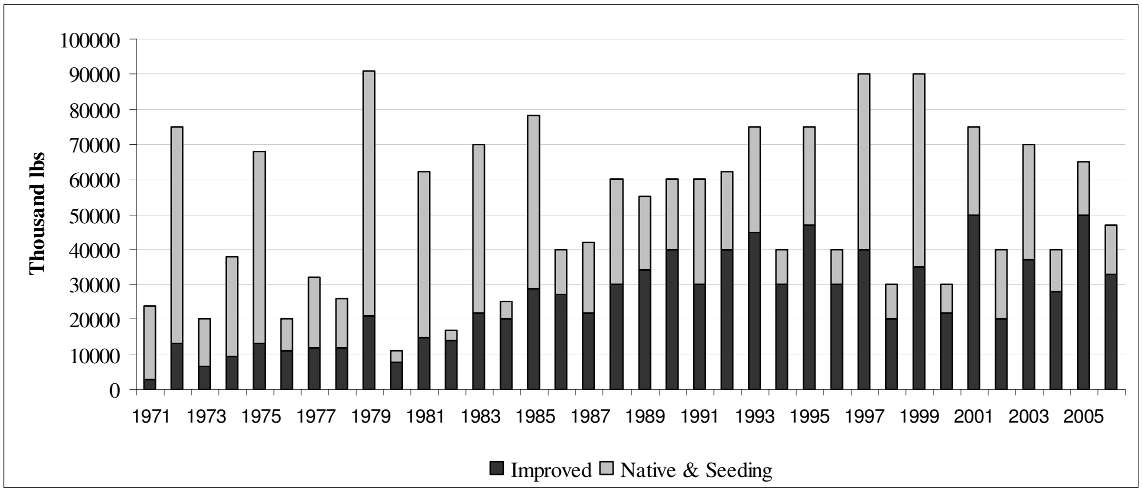

Figure 2.9: Texas Utilized Production by Variety, 1971-2006 (USDA 2006)

other hand, producers of improved varieties always harvest and tend to hold their crop until prices become more desirable. These producer behaviors limit consumer purchases by constraining what is available for sale, especially in the case of native pecan sales because of their already higher than improved yield fluctuations.

Sales of native pecans, although possibly driven by price, are more determined by availability for sale. According to one producer and member of the Texas Pecan Board, the harvest of native pecans is determined primarily by the magnitude of the crop (Adams et. al. 2007), meaning that even though sales of native pecans are influenced by price, sales are driven primarily by the availability of the supply for sale.

The value of Texas pecan production has been increasing over the past thirty years (Figure 2.10) with the majority of the growth attributed to the development and implementation of improved varieties. Prices for improved varieties tend to be higher

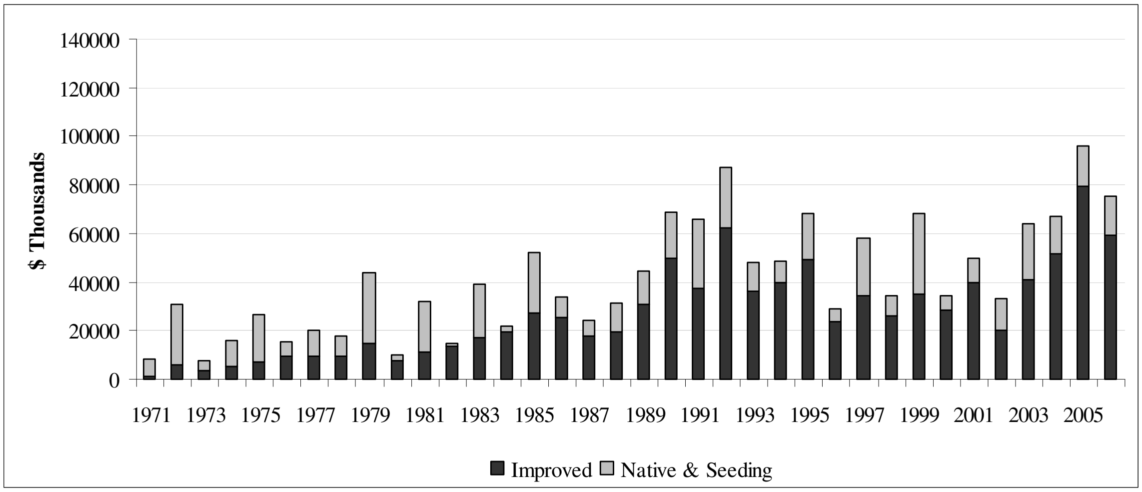

Figure 2.10: Texas Value of Pecan Production by Variety, 1971-2006 (USDA 2006)

than those of native/seedling varieties because of higher meat content and greater quality in the nuts (see Figure 2.1).

Sales for improved varieties have been increasing over the past thirty years just as sales for native/seedling varieties have been on the decline. The transition being made by Texas pecan growers from native to improved pecans due to changes in consumer demand can be seen in Figure 2.11. The average sales of Texas pecans over the past decade were approximately 57 million pounds, up 17.2 million pounds or 42% from the 1970s. The 17 million pounds in growth is made up of a 22.6 million pound increase (growth of 207%) in the improved varieties and 5.4 million pound decrease (loss of 18%) in native/seedling varieties (1971-2006).

The sales of native pecans are also much more volatile than those of improved pecans (see Figure 2.11). To empirically compare the difference between native and

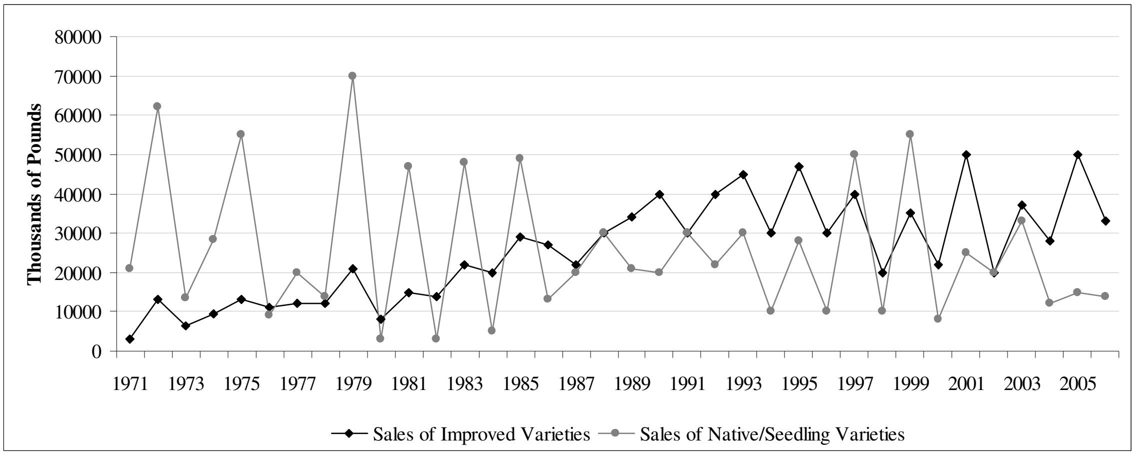

Figure 2.11: Sales of Improved and Native Varieties, 1971-2006 (USDA 2006)

improved pecans in sales volatility, the coefficients of determination (c_v) can be calculated for both improved and native pecan sales as:

$$c_v = \frac{\sigma}{\mu} \tag{2.1}$$

where σ is the standard deviation and μ is the mean. The coefficients of determination are 0.50 and 0.69 for improved and native pecan sales respectively, suggesting that native pecan sales are more volatile than improved pecan sales. Although improved varieties typically do not experience the volatility in production that native varieties experience, the change in production of improved varieties from 2001 to 2002 was the largest nominal variation from an on year to an off year. According to the USDA Crop Production Reports (USDA 2001; USDA 2002), early season growing conditions were excellent during 2001 including above average rainfall which combined with the alternate bearing cycle (on year) contributed to the high availability of pecans for sale in 2001. However in 2002, unreasonable rains and wind due to tropical storms during

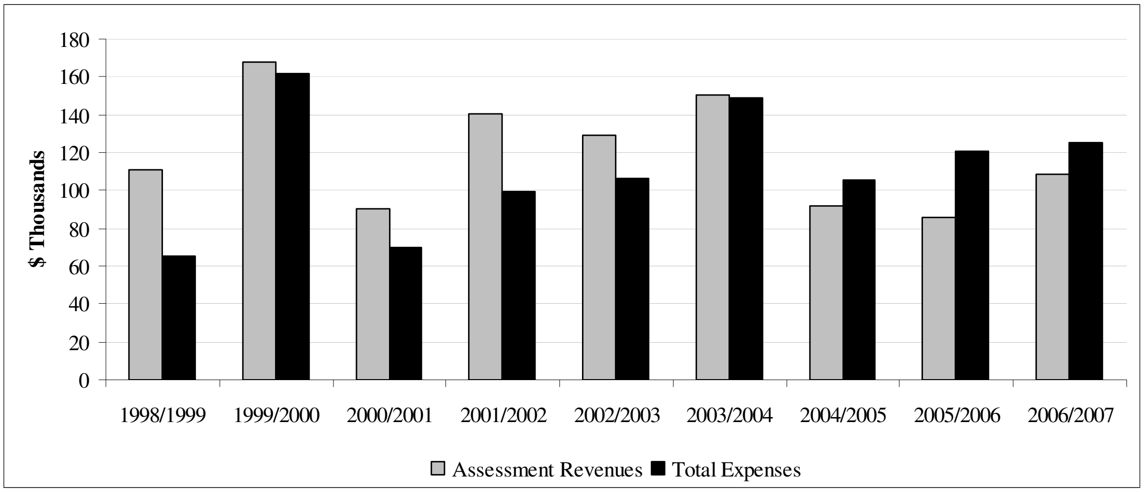

Figure 2.12: Texas Pecan Board Crop Year Assessment Revenue and Expenditures, 1998/99 – 2006/07

October and November delayed and reduced harvests in terms of quantity and negatively affected quality through increased diseases (USDA 2002). These weather factors combined with the alternate bearing cycle (off year) produced a record low crop for improved varieties.

Texas Pecan Board Promotion Efforts

Although the Texas Pecan Board was established in 1998, their first year of promotion did not occur until crop year 1999/2000. Revenues to support the promotion efforts of the Board come from a one-half cent per pound assessment on all pecans sold from growers to a first handler and have varied between $85,500 and $167,600 thousand per crop year (Figure 2.12). Expenses in crop year 1998/1999, which were solely administrative costs, were $65,200. Since then, total expenses have varied between

$70,100 and $161,600. Revenues from the assessment fees were at their highest during the 1999/2000 crop year, but have been on the decline ever since.

Of the total expenses by the Texas Pecan Board, annual expenditures on promotion have ranged from $58,700 and $145,200 with an average of $90,600. For the purpose of this analysis in understanding the Texas Pecan Board advertising expenditures, Texas Pecan Board promotion expenses have been divided into seven categories: (1) ambassador program, (2) festivals and conferences, (3) clipping service, (4) research, (5) website, (6) media, and (7) other promotion (Figure 2.13). The Texas Pecan Board has hired three separate entities to manage their promotion efforts over the years: Oldfield Davis Inc., and two private marketing agents.

Unfortunately, due to ambiguous record keeping, invoices made out to Oldfield Davis Inc. from 1999-2002 were not given a proper description. Consequently, administrative costs incurred by Oldfield Davis could not be subtracted out of the promotion payments. The Oldfield Davis promotion expenses were categorized as media based on the working knowledge of the Texas Pecan Board's bookkeeper. In consideration of administrative costs in the Oldfield Davis invoices, advertising fees to private advertising agents from 2002-2007 were included in the media category to maintain uniformity in the data. If looking at the *other promotion* category which included the Oldfield Davis invoices and other agent fees, the *media* category increased dramatically after 2002 (when the Texas Pecan Board quit using Oldfield Davis) and *other promotion* decreased accordingly. This supports the hypothesis that the promotion invoices are primarily media expenditures.

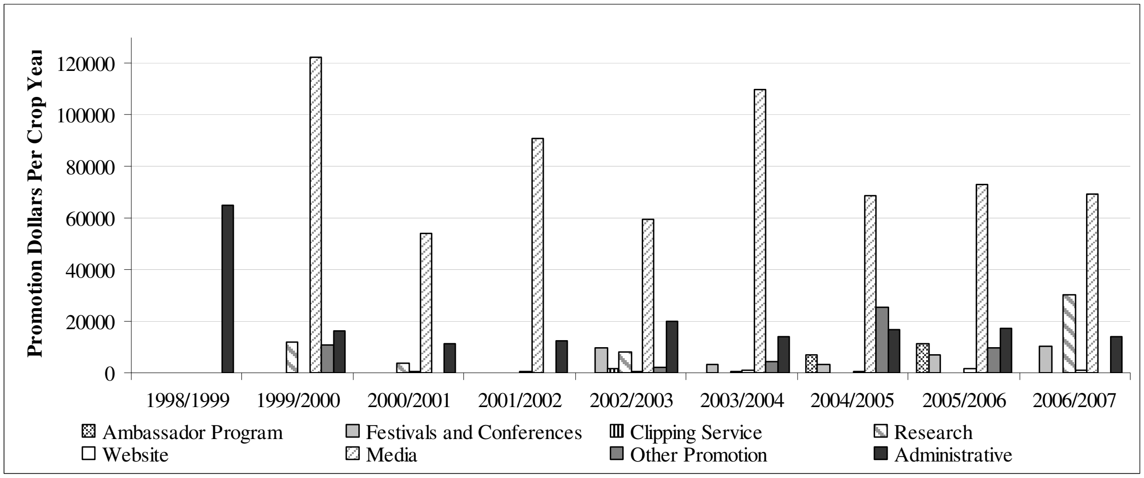

Figure 2.13: Texas Pecan Board Expenditures by Category

The *ambassador program* includes covered travel, conference fees, and a small stipend for a representative that promotes pecans and the Texas Pecan Board. The *festivals and conferences* category includes expenses associated with the annual State Fair and Pecan Festival such as prize money for pecan cook-offs, posters and radio advertisements for the fair, fair fees, and other miscellaneous fair and festival expenses. The *clipping service* expenses occurred between 2002 and 2003 and paid for the collection of articles and stories from media outlets (including television, newspapers, and the internet) regarding pecan promotion in the state of Texas. The *research* category includes expenses for health benefit studies, promotion evaluation research, and a benchmark study. The *website* category includes expenses for hosting, maintaining, and registering the Texas Pecan Board website which hosts a variety of promotion literature including recipes and health benefits. The *media* category is the largest expense category and includes expenses for radio advertisements, a promotional video, magazine articles and advertisements, recipe booklets, posters, other publications, and fees paid to advertising agents. The *other promotion* category includes expenses not included in one of the previous six categories and either ambiguous promotion expenses such as payments with no detailed description, one time projects such as a project in St. Louis, or miscellaneous promotion expenses such as grower packets, contributions to other pecan research, t-shirts and hats, presentations, and booth fees for special events. The largest expense categories over the life of the Texas Pecan Board are media, administrative, research, and other promotion (Figure 2.14). Promotion categorized as *media* represents more than 60% of total promotion expenditures. Because it is difficult to compare the minor categories in a Figure 2.13, the minor promotion categories are detailed in Figure 2.15.

Summary

Improved and native are the two varieties of pecans which differ physically as well as in use. Improved pecans are those varieties that have been genetically altered through selection and crossing in order to display preferred characteristics such as physical size, resistance to diseases and insects, and resistance to alternate-bearing yields. Improved are typically used in household consumption, whereas native pecans are generally used for industrial food production in candies, pastries, and other foods. Because of the difference in uses and because the Texas Pecan Board promotes

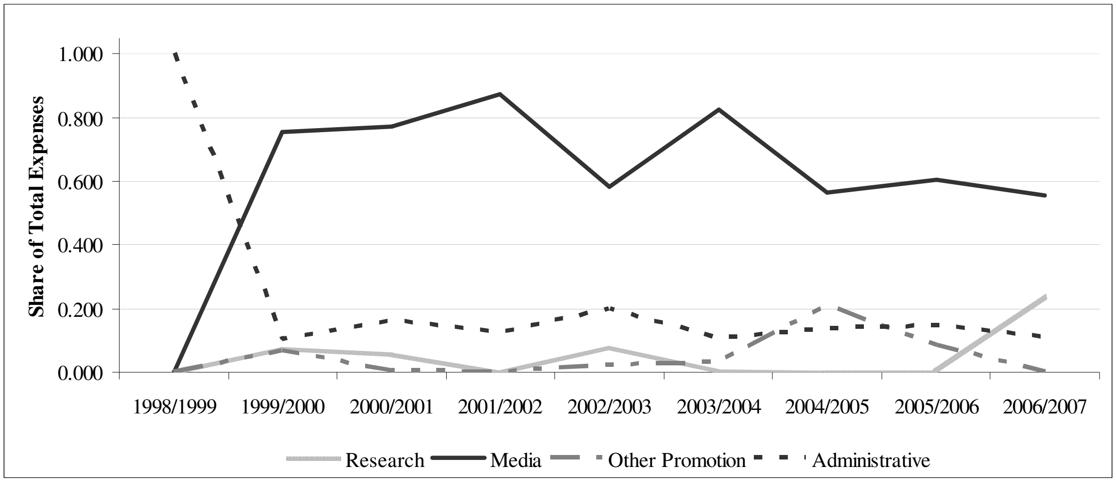

Figure 2.14: Categories with Largest Share of Total Expenditures, 1998/1999-2006/2007

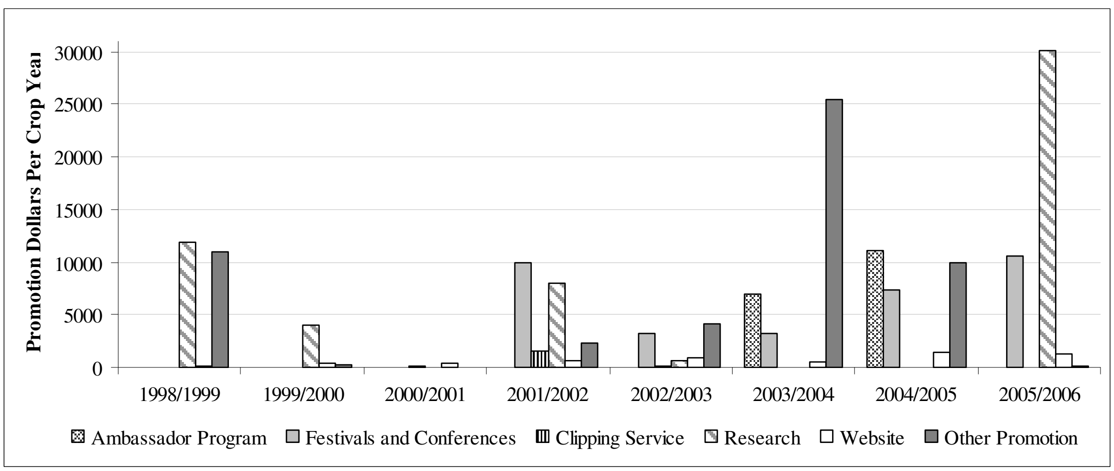

Figure 2.15: Texas Pecan Board Promotion Expenditures Excluding Media, 1998/1999-2006/2007

household consumption, the Texas Pecan Checkoff Program may have had a greater impact on improved than native pecans.

The U.S. pecan industry produces over 80% of the world's supply of pecans, however the U.S. is still a net importer. Pecans are grown throughout the U.S. from California to North Carolina with Georgia, Texas, and New Mexico being the lead producing states. Texas pecan sales have been increasing over the past thirty years. The majority of the growth is attributed to improved pecan sales, while native pecan sales have actually declined over the past thirty years.

One major difference between native and improved pecan growers is that native pecan growers do not always harvest their crop, which adds to the issue of changing availability of pecans for sale each year. This difference in grower behavior in conjunction with the fact that native pecans experience more dramatic yield variations than improved variations which in turn affects availability, suggests that availability may have a greater impact on sales of native pecans than improved pecans.

The qualitative analysis determined that the factors likely affecting the demand for Texas pecans include the prices of pecans, almonds, and walnuts; disposable income, variations in availability, the structural change in the pecan industry from consumption of native varieties to improved varieties of pecans over time, and the Texas Pecan Board promotion expenditures.

CHAPTER III

CONCEPTUAL MODELS AND DATA

The evaluation of the effectiveness of the Texas Pecan Promotion Program on pecan sales can be easily expressed conceptually. Pecan sales are simply what is demanded by consumers. Thus, a shift in the demand curve after the initiation of a promotion program provides a measure of the effect of the promotion program on demand and, therefore, sales. This study is an effort to determine if the promotion program has in fact caused a shift in demand as depicted in Figure 3.1. Supply is assumed to be perfectly elastic in Figure 3.1 because the objective of the research is to determine how demand would change in terms of quantity without a price effect, ceteris paribus. The magnitude of the shift in demand can be measured by the change in quantity demanded from Q_0 to Q_N (Figure 3.1). The problem with this measurement is that in reality, there is potentially a supply response to the change in demand. Thus, the actual change in quantity demanded as a result of promotion will be less than indicated in Figure 3.1. Nevertheless, unless supply is perfectly inelastic, a shift in demand will have an impact on sales.

Early efforts to evaluate a promotion program looked at total sales and total promotion expenditures and attempted to determine if there was some relationship between the two (Williams, Capps, and Palma 2007). The problem is that sales are affected not only by changes in promotion expenditures but also changes in prices, policies, inflation, availability of supply, and a host of other variables. Looking only at

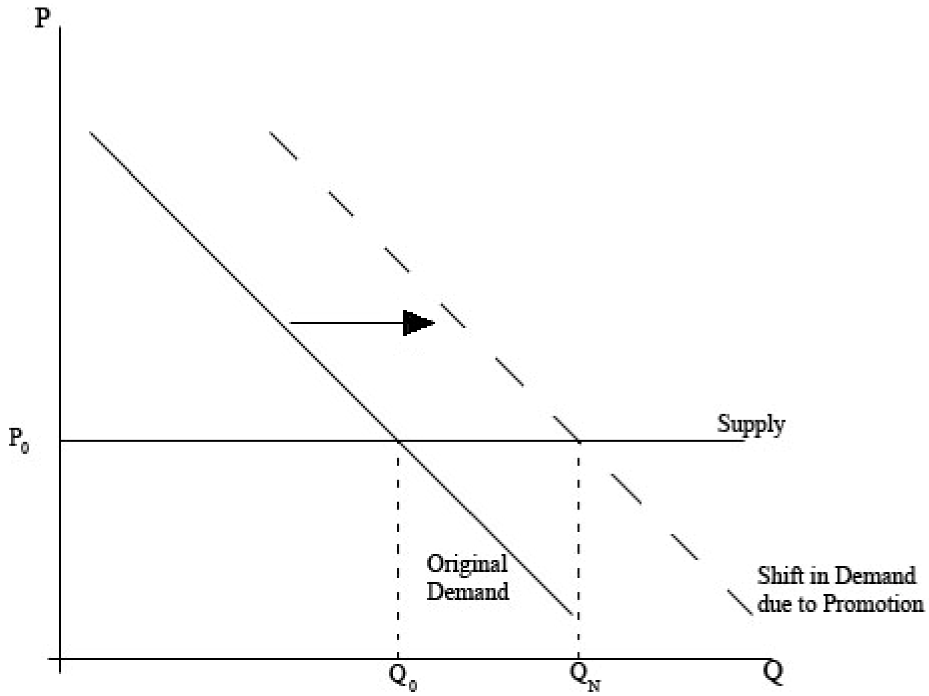

Figure 3.1: Illustration of the Shift in Demand for Texas Pecan Due to Promotion

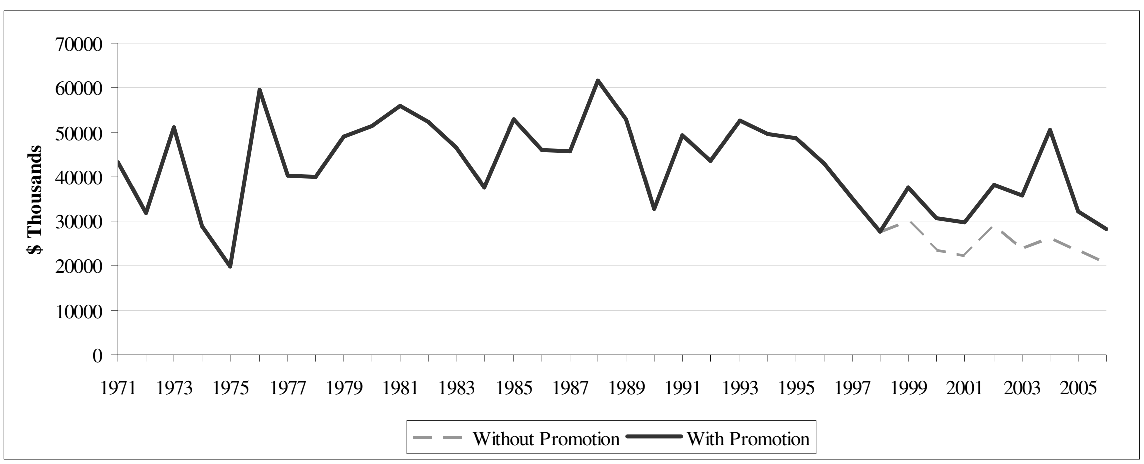

Figure 3.2: Illustration of the Possible Historical Paths of Sales With and Without Promotion

promotion expenditures and sales does not consider the “path change” that may have taken place as a result of promotion and only considers the correlation between promotion expenditures and sales. Thus, the program that takes credit for rising sales in good years must also take responsibility for declines in sales during bad years. Furthermore, declining sales after the initiation of a promotion program does not necessarily mean the program is ineffective because sales could have been even lower if the program had not been in place (see Figure 3.2). As a result, more sophisticated statistical techniques than simply considering the correlation between sales and promotion expenditures are necessary to capture the effect of promotion on sales.

Econometric regression has been the most prevalent empirical technique used to statistically separate the effects of promotion expenditures and other variables on sales and demand (Williams, Capps, and Palma 2007). Econometric regression techniques allow the analyst to statistically measure the contribution of multiple variables in determining the sales, including expenditures on promotion. In essence, regression procedures isolate and measure the effects of changes in promotion expenditures and those of other major market forces on changes in sales over time.

Furthermore, statistical tests based on regression results aid the analyst in identifying those market forces and relationships that are the major drivers of sales and most accurately explain changes in sales over time. For example, the coefficient of determination (R^2) is a measure of the variation in the dependent variable (sales of pecans in this case) accounted for by the estimated model where variation is measured as the sum of squared errors. The Akaike Information Criterion (AIC) is another measure of goodness of fit that penalizes models for every additional variable introduced into the model. Thus, the AIC not only rewards goodness of fit as does R^2, but also commends parsimony.

The successful expansion of demand and increase in consumption is not the only relevant issue when evaluating a promotion program. Even if the statistical analysis determines that the program successfully shifts out demand, the cost of the corresponding promotion must not exceed the benefits of the program or the program would be “unsuccessful” even though demand was increased. Consequently, most analyses of promotion programs calculate a payoff ratio for the program such as the benefit-cost ratio. The benefit-cost ratio basically provides a measure of how many dollars of revenue are created for every dollar spent on promotion. In essence, the basic question is whether the benefits in terms of increased revenue from shifting demand (as depicted in Figure 3.1) are greater than the cost in terms of the checkoff assessments spent on promotion.

Because this is the first such analysis of the effectiveness of the Texas Pecan Checkoff Program, there is no previous research that evaluates the program on which to build or with which to compare. However, the evaluation of national pecan promotion efforts and those of other checkoff programs operated by the Texas citrus industry and the California almond industry provide guidance on appropriate methodologies and procedures to successfully analyze the Texas Pecan Checkoff Program (Alston et al. 2006).

Econometric Models

The purpose of this analysis is to evaluate the effectiveness of the Texas Pecan Checkoff Program in shifting the demand for Texas pecans. Based on previous related research and the qualitative analysis of the U.S. and Texas pecan industries in the previous chapter, three econometric models (Table 3.1) will be tested to explain the effect of Texas Pecan Board promotion expenditures on:

1) Texas sales of improved and native varieties combined;
2) Texas sales of improved varieties of pecans, and
3) Texas sales of native and seedling varieties of pecans.

For model (3.1) in Table 3.1, the combined or aggregate model, the OLS estimator will be used to estimate the model parameters. It is hypothesized that the relevant variables in determining sales of all pecans are Texas Pecan Board promotion expenditures, price of all pecans in real terms, price of almonds in real terms, price of walnuts in real terms, availability of pecans, disposable income in real terms, and a structural variable representing the change in consumption from native to improved pecans (see Table 3.1).

Models (3.2) and (3.3) will be estimated separately in order to test whether Texas Pecan Board promotion has had a greater impact on sales of improved varieties than native pecans. The Texas Pecan Board Promotion Program has targeted household consumption of pecans through festivals and conferences, media advertisements, recipes at grocery stores, etc. Typically, pecans purchased by households are improved

Table 3.1: Conceptual Pecan Models, Structural Specifications, and Variable Definitions

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Conceptual Models

(3.1) *PECSALALL=f(RPECPROME, RPECPRALL, RALMPR, RWALPR, AVAIL, DISPINC, STRUCT)*

(3.2) *PECSALIM=f(RPECPROME, RPECPRIM, RALMPR, RWALPR, AVAIL, DISPINC, LAGPECSALIMP, STRUCT, ANOM)*

(3.3) *PECSALNS=f(RPECPROME, RPECPRNS, RALMPR, RWALPR, AVAIL, DISPINC, LAGPECSALNS)*

Definitions

PECSALALL	Texas sales for both improved and native pecan varieties, thousand lbs
PECSALIMP	Texas sales of improved pecan varieties, thousand lbs
PECSALNS	Texas sales of native pecan varieties, thousand lbs
RPECPROME	Texas Pecan Board promotion and advertising expenditures, dollars
RPECPRALL	Average Texas pecan price received by growers, cents/lb
RPECPRIM	Average Texas improved pecan price received by growers, cents/lb
RPECPRNS	Average Texas native/seedling pecan price received by growers, cents/lb
RALMPR	Average almond price received by growers, cents/lb
RWALPR	Average walnut price received by growers, cents/lb
AVAIL	Availability of pecans using the proxy yield, pounds per acre
DISPINC	Disposable personal income of United States, dollars
LAGPECSALIMP	Lag of sales of improved varieties, thousand lbs
LAGPECSALNS	Lag of sales of native varieties, thousand lbs
STRUCT	Binary variable representing the structural change from 1977-2006
ANOM	Binary variable representing a drastic change in availability from 2001-2002

varieties, whereas native varieties are used in production of candies, baking goods, and other food products (Worley 1994). Therefore, because the Texas Pecan Board may have indirectly targeted consumption of improved pecans, promotion may have a greater impact on sales of improved varieties than on native pecans.

The parameters of models (3.2) and (3.3) will be jointly estimated using the seemingly unrelated regression (SUR) estimator because the models are conceptually related to one another in that models (3.2) and (3.3) are two demand equations for similar commodities with similar variables (Pindyck and Rubinfeld 1996). When estimating two conceptually related equations, there is a potential for correlation between the error terms of the two equations. If the disturbance terms are related, the SUR model is an appropriate technique for addressing cross-equation error correlation, and will result in more efficient parameters. If the disturbances or error terms of these two models are unrelated, then there is no relationship between the two models and the empirical results will be the same as estimating the parameters of the two models separately using the ordinary least squares (OLS) regression assuming that each variable has the same number of data points.

Prices, Disposable Income, and Availability

Prices of pecans are a significant variable in a demand equation because consumer purchasing decisions are constrained by a budget. As discussed in the previous chapter, almonds and walnuts are the closest substitutes for pecans and provide an alternative for consumer purchases. Therefore, the prices of almonds and walnuts may impact the demand for pecans. If the price of almonds or walnuts increases, theory would suggest that demand for pecans would increase, whereas consumption of pecans would decrease if the price of almonds or walnuts decreased. Furthermore, because consumer purchasing decisions are subject to a budget constraint, their ability to purchase pecans is limited by their disposable income. U.S. per capita disposable income is included in all three demand equations to account for this budget constraint.

As discussed in the previous chapter, the availability of pecans for sale provides a constraint on consumer purchases. The availability is affected by the alternate-bearing nature of the pecan, which limits the quantity of pecans produced and ready for sale. Therefore, availability is included in models (3.1), (3.2), and (3.3). This term uses the yield as a proxy, which measures the variation of production per bearing acre. It is likely that the availability term will have a greater impact on native pecan sales than improved pecan sales because improved varieties have been genetically altered through selection and crossing in a way to minimize the effects of the alternate-bearing nature of the pecan.

Habit Persistence

Unlike model (3.1), models (3.2) and (3.3) include a lagged dependent variable which models how consumer demand changes dynamically rather than instantaneously due to habit persistence. Habit persistence suggests that as price changes, consumers spread their response over some period of time instead of changing their demand immediately because of their habit or tendency to purchase the old commodity, in this case native pecans. Habit persistence is not relevant for the aggregate pecans sales demand, model (3.1), because native and improved pecans are substitutes. As consumers are switching their consumption of pecans from native to improved, the dynamic effects of decreasing sales of native pecans combined with increasing sales of improved pecans creates an offsetting effect in the aggregate equation.

Following a discussion by Labys (1973) on the explanation of the dynamic theory of Nerlove and the Nerlovian partial adjustment mechanism, changes in pecan demand from one period to the next will vary in proportion to the change in pecan consumption between past and long run equilibrium consumption. This change is defined as:

(3.4) $$Y_t - Y_{t-1} = \Delta\left(Y_t^L - Y_{t-1}\right)$$

where $Y_t - Y_{t-1}$ is the change in consumption from one period to the next, Y_t^L is the theoretical long-run equilibrium consumption, and Δ is the rate at which demand adjusts. Consider the following model of long-run equilibrium pecan consumption where *PROM* is Texas Pecan Board promotion expenditures, *PRICE* is the price of pecans received by growers, and *Z* represents other relevant variables:

(3.5) $$Y_t^L = \alpha_0 + \alpha_1 PROM - \alpha_2 PRICE + \alpha_3 Z$$

Substituting equation (3.5) into equation (3.4), we obtain the following dynamic relationship for pecan demand:

(3.6) $$Y_t - Y_{t-1} = \Delta\alpha_0 + \Delta\alpha_1 PROM - \Delta\alpha_2 PRICE + \Delta\alpha_3 Z - \Delta Y_{t-1}$$

which can be rearranged to form:

(3.7) $$Y_t = \Delta\alpha_0 + \Delta\alpha_1 PROM - \Delta\alpha_2 PRICE + \Delta\alpha_3 Z + (1-\Delta)Y_{t-1}$$

or simplifying, we can compute the estimated coefficients (β) in the demand model:

(3.8) $$Y_t = \beta_0 + \beta_1 PROM - \beta_2 PRICE + \beta_3 Z + \beta_4 Y_{t-1} + \varepsilon_t$$

where ε_t is the random, normally distributed residual.

As discussed in the previous chapter, the Texas sales of native pecans have been trending downward over the years while Texas sales of improved pecans have been trending upward (see Figure 2.11). The inversely related slopes of the native and improved variety sales reflect the growing tendency of Texas pecan producers over time to switch from low meat and highly volatile yielding native pecans to high meat and less volatile yielding improved pecan varieties. The offsetting trends in the sales of improved and native Texas pecans result in little trend in aggregate sales (Figure 3.3). Both native and improved prices are not included in the SUR equations, as they are hypothesized to be collinear due to a high correlation of 0.93 (Table 3.2). Nevertheless, multicollinearity, specifically between these two variables, will be tested using the variance inflation factor statistic, which measures the degree to which one independent variable is a linear combination of the other independent variables, and is calculated as:

(3.9) $$VIF_j = \frac{1}{1-R_j^2}$$

where R_j^2 is the coefficient of determination for the j^{th} variable as a function of the other regressors.

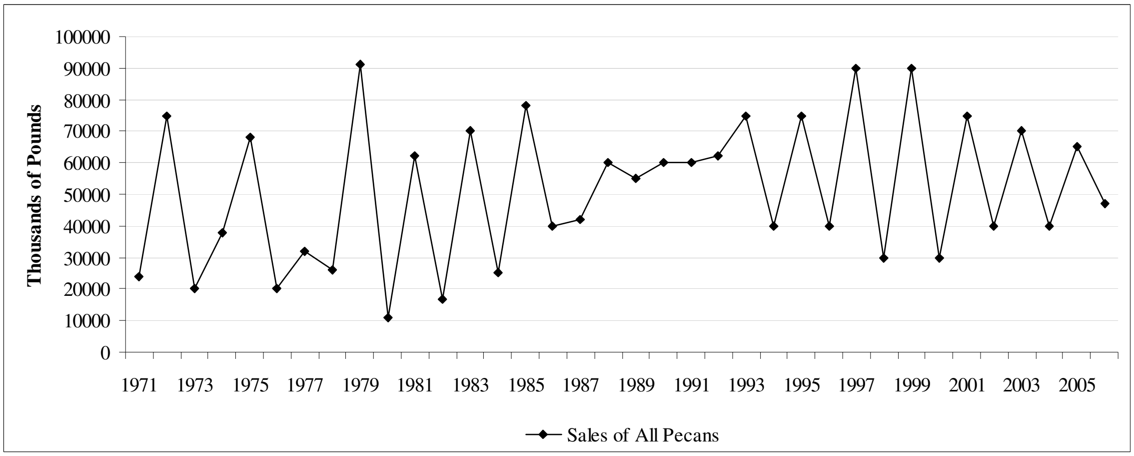

Figure 3.3: Sales of Improved and Native Pecan Varieties Combined, 1971-2006 (USDA 2006)

Promotion Data

Promotion expenditures today may not immediately affect consumer decisions, implying the existence of delayed benefits, or carryover effects. To address this issue, promotion expenditure data can be lagged in the model to account for their effect in the future. Two common lag structures are the polynomial distributed lag (PDL) and the geometric lag. The PDL is specified as:

(3.10) $$Y_t = \beta_0 + \beta_1 (w_0 X_t + w_1 X_{t-1} + \cdots + w_n X_{t-n}) + \varepsilon_t$$

where

(3.11) $$w_i = c_0 + c_1 i + c_2 i^2 + c_3 i^3 + \cdots + c_n i^n \qquad \text{for } n \text{ lags}$$

where *w* represents the specified lag weights on variable *X*, and *c* is the coefficient for determining the lag weight based upon a specified number of lags (*n*).

The PDL allows the lag weights to be specified by a continuous function, which in turn can be approximated by evaluating a polynomial function. Furthermore, the PDL is flexible in the shape of the lag formation allowing for humped-shaped or monotonically decreasing lag weight distributions. To determine the length and polynomial degree of the distribution, it is necessary to run a number of regression estimations with varying degrees and lags (Almon 1965). Endpoint restrictions for the lag can be determined using the Akaike Information Criterion (AIC) and Schwarz Information Criterion (SIC).

The geometric lag is more parsimonious in concept and application in that only weights have to be specified instead of estimating a polynomial, which provides it some advantages over the PDL by allowing easier specification of the desired lag weights. In general, the geometric lag can be specified as:

$$Y_t = \beta_0 + \beta_1 X_t + \beta_1 X_{t-1} + \cdots + \beta_n X_{t-n} + \varepsilon_t = \beta_0 + \sum_{n=1}^{\infty} \beta_n X_{t-n} + \varepsilon_t \qquad (3.12)$$

Although the geometric lag structure assumes a geometrically declining set of lag weights (Pindyck and Rubinfeld 1991), this does not become an issue when using a low number of lags. Given that our data is crop-year data, it is unlikely promotion efforts will be lagged more than two or three periods. More complex lag structures such as rational distributed lags exist; however, provide few advantages over the parsimonious geometric and PDL models. The number of lags is limited because the data is annual. The geometric lag as well as the PDL will both be tested to measure the carryover effects of Texas Pecan Board promotion expenditures. The lag structure that minimizes the AIC will be implemented in the final model.

Binary Variables

Not all variables that affect demand can be easily quantified. These qualitative variables are often events that affect demand for some period of time. Two events have had a major impact on the demand for Texas pecans: (1) the transition in consumer demand from native to improved pecans, and (2) a change in production from 2001 to 2002 that was the largest nominal variation in sales from an on year to an off year for improved varieties. As discussed in the previous chapter, Texas producers have been switching from native pecans to improved pecans over the past few decades. This process takes time as it requires approximately ten years for a planted tree to reach its maximum production potential. A distinct transition from native to improved pecans can be seen in the sales data from about 1976 to the present. Since 1976, Texas production of improved pecan varieties has been on an upward trend while that of native pecan production has been on a downward trend. The analysis will test the statistical significance of event (1) on sales of Texas pecans by using a binary variable (*STRUCT*) for 1977 to the present. The statistical significance of even (2) in determining sales of improved pecans will be tested using the binary variable *ANOM* for the crop year 2001/2002.

To account for the shift in demand from event (2), a binary variable for 2001/2002 will be tested for statistical significance. Improved pecan varieties have contributed substantially to the overall production of pecans in Texas in recent history. As mentioned in the previous chapter, one of the qualities that has enticed pecan growers to switch from native to improved pecans is that improved pecans are less susceptible to the “on” and “off” yield variations that are biologically more pronounced in native pecans. As seen in Figure 3.4, the 30 million lb decline from 2001 to 2002 was the largest variation in improved production over the period of the data. This drastic change took place due to a phenomenal “on year” in 2001 which tied for the highest improved production in Texas followed by a detrimental “off year” in 2002 which tied for the lowest improved production since 1982.

Benefit-Cost Analysis

Four benefit-cost ratios will be calculated using the parameters from the measurement of the effectiveness of promotion expenditures in increasing sales including a revenue BCR (PBCR), net revenue BCR (BCR), discounted BCR (DBCR), and sales BCR (SBCR). The revenue BCR is simply the ratio of gross benefits to gross costs. The net revenue BCR is the most appropriate measure of the benefit-cost ratio in terms of additional benefits because it nets out the cost of promotion from the generated additional revenues. The sales BCR measure will identify the number of sales dollars generated for every dollar spent on promotion. As depicted in Figure 3.2, net revenues are determined by multiplying the price received by producers in each period by the distance between the observed path of sales that occurred with promotion and the unobserved path of sales that would have occurred had promotion not existed at a given period.

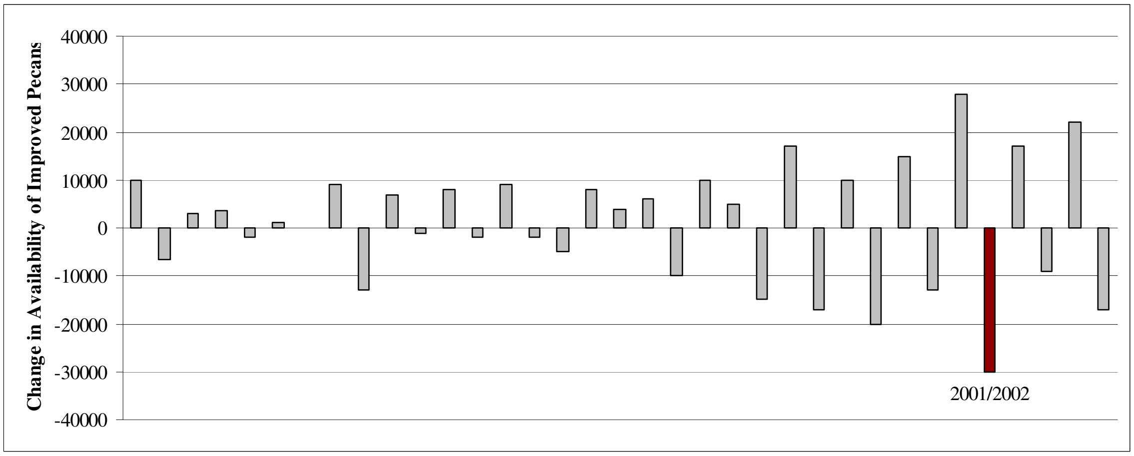

Figure 3.4: Change in Improved Production from One Year to the Next, 1971/1972 to 2005/2006 (USDA 2006)

In principle, the net revenue BCR is calculated as net revenues divided by the cost of the promotion where net revenues is the difference between gross revenues generated from additional utilization and the cost of the promotion.

(3.13) $$BCR = \frac{\sum_{t=1}^{n} R_t - \sum_{t=1}^{n-1} PROM_t^N}{\sum_{t=1}^{n-1} PROM_t^N}$$

where $\sum_{t=1}^{n} R_t$ is total additional revenues in nominal terms, and $\sum_{t=1}^{n-1} PROM_t^N$ is total costs in nominal terms.

Simulation Method of Calculating the BCR

Building upon equation (3.13), the total additional revenues (or total benefits) must be calculated in order to compute a BCR. Calculating the total benefits for a specific year of promotion requires the calculation of the estimated impact that promotion had on sales. One way of performing this computation is by using simulation. Suppose sales (Y_t) is a function of promotion expenditures ($PROM_t$), other variables (Z_t), and an error term (ε) for t=1, 2, …, n and j=1, 2, …, k where t is the number of years and k is the number of lags (j) such that:

(3.14) $$\hat{Y}_t = \lambda_0 + \lambda_1 Z_t + \lambda_2 PROM_t + \lambda_3 PROM_{t-1} + ... + \lambda_{k+2} PROM_{t-k}$$

Setting all promotion expenditures equal to zero provides a representation ($\hat{Y}_t$) of what would have occurred had promotion not taken place:

(3.15) $$\hat{Y}_t^*(PROM_t = 0) = \lambda_0 + \lambda_1 Z_t + \lambda_2 \times 0 + \lambda_3 \times 0 + ... + \lambda_{k+2} \times 0$$

To calculate the total benefits (*TB*) from the promotion efforts during a specific year, the promotion impact on sales in year t must be multiplied by the price received by growers (P_t) during that same period. This calculation of the total benefits can be done by solving equation (3.14) above for $\hat{Y}_t$ and subtracting from it $\hat{Y}_t^*(PROM_t = 0)$ in equation (3.15), yielding the total benefits (*TB*) for a given year:

(3.16) $$TB_t = P_t\left(\sum_{j=0}^{k} \lambda_t PROM_{t-j}\right) \quad \text{where } [t = 2000, 2001, ..., 2006]$$

The net revenue BCR for a specific year can then be calculated by dividing by the cost of promotion. Summing the total benefits over all n years (2000 through 2006) and substituting into equation (3.13) yields the BCR for the history of the promotion program:

(3.17) $$BCR = \frac{\sum_{t=1}^{n}\sum_{j=0}^{k} P_t \lambda_t PROM_{t-j}}{\sum_{t=1}^{n-j} PROM_t} - 1$$

The BCR+1 yields the revenue BCR, which is a measurement of dollars generated per dollar spent on promotion. Discounting the BCR back to its present value provides the discounted BCR.

A sales BCR will also be calculated, which ignores the price and calculates the benefits as a quantity rather than a monetary value. The sales BCR provides an alternative indication of the effectiveness of the promotion program that is not dependent upon the price received by growers. The sales BCR, which describes the increase in sales for every dollar spent on promotion, can be calculated by setting $P_t = 1$ in equation (3.17) yielding:

(3.18) $$SALES\ BCR = \frac{\sum_{t=1}^{n}\sum_{j=0}^{k} \lambda_t PROM_{t-j}}{\sum_{t=1}^{n-j} PROM_t}$$

where $\sum_{t=1}^{n}\sum_{j=0}^{k} \lambda_t PROM_{t-j}$ is the total change in sales (Y_t) from promotion expenditures, and $\sum_{t=1}^{n-j} PROM_t$ is the total cost of the promotion that has generated benefits.

Using the Elasticity to Compute the BCR

The change in sales due to promotion ($\sum_{t=1}^{n}\sum_{j=0}^{k}\lambda_t PROM_{t-j}$) that is used to calculate the total benefits in equation (3.13) can be computed alternatively using the elasticity of promotion. Following Williams, Capps, and Palma (2007), the elasticity of promotion is interpreted as the percent change in sales due to a percent change in promotion. Therefore, multiplying the elasticity of promotion (e_t^{PROM}) in a given period by the actual quantity of sales in a given period yields the additional sales (ΔY_t) due to promotion:

(3.19) $$\Delta Y_t = e_t^{PROM} \times Y_t$$

The change in sales can be multiplied by price in year *t* and summed over all *n* years in order to yield total benefits. The elasticity calculation of the BCR may differ slightly from that of the simulation method for two reasons. First, the elasticity calculation uses an arc elasticity rather than the same coefficient for each time period in the computation of the change in sales due to promotion. Second, the simulation effect will have to be manipulated because of the log-log transformation in order calculate the correct change in sales rather than the change in log of sales.

Descriptions of Data

Texas pecan sales data were collected from the Economic Research Service (ERS) of the USDA Fruit and Tree Nut Reports over the 1971-2006 period. Those reports provide crop year utilized production by state. Pecan sales data are also provided by the reports but only on a national level and not at the state level. Interestingly enough, USDA defines national sales as being equivalent to national utilized production. Consequently, the terms “sales” and “utilized production” are used interchangeably in this study. Texas utilized production is reported in thousands of pounds per crop year for all pecans and disaggregated into utilized production of improved varieties and of native and seedling varieties.

Prices for pecans, almonds, and walnuts were also collected from the USDA Fruit and Tree Nut Reports. These prices represent average grower prices received during a crop year and were measured in cents per pound. Prices have been deflated by the consumer price index to account for inflation, creating “real” or “deflated” prices. 30-day Treasury Bill (T-Bill) rates were collected from the International Financial Statistics published by the International Monetary Fund.

Promotion expenditures were collected from the Texas Pecan Growers Association, which is the agency that keeps the accounting records for the Texas Pecan Board. Although the Board was created in 1998, promotion expenditures did not commence until crop year 1999. The Texas Pecan Growers Association (TPGA) maintains records of expense by the Board over the years. The data as provided by the Texas Pecan Growers Association were compiled on a crop year basis because prices and sales are reported on a crop year basis[3]. Zero values were inputted for crop years 1971 through 1998 prior to the establishment of the Texas Pecan Board since there was no promotion of Texas pecans prior to 1999.

[3] The Texas pecan harvesting and marketing seasons typically take place between September 15 and January 31. The crop year was measured as September 15 and the succeeding 12 months.

Unpublished total bearing pecan acreage[4] data for Texas were collected from the USDA-NASS office in Austin, Texas in order to compute pecan yield for all, improved, and native pecans as a proxy for availability. These data were measured by the Census of Agriculture for the years 1969, 1974, 1978, 1982, 1987, 1992, 1997, and 2002. This study estimated 2007 acreage using a trend regression on the census data from 1982 through 2002. The census has taken place every five years since 1982, so census estimates from 1969, 1974, and 1978 were not used in the 2007 forecast because they were not measured at the same interval length as the most recent censuses. As the data provided did not include intermediate values between each census, these values were interpolated in order to maintain continuity in the data. The interpolation was computed by evenly distributing the difference between two censuses across the intermediate years. The total acreage data are used to compute the average production of pecans per acre for all, improved, and native pecans over time. This is calculated as utilized production divided by total bearing acreage. As discussed in the previous chapter, yield will act as a proxy for availability.

Disposable income and population statistics for the state of Texas were collected from the Bureau of Economic Analysis (BEA) for the data range from 1971 through 2005. Unfortunately, the 2006 estimates were not available at the time of this study. To save one degree of freedom, however, the analysis will use BEA preliminary estimates for 2006 disposable income and population. Disposable income and population of Texas will not be used simultaneously due to the theoretical similarity and high correlation

[4] Total acreage for pecans was calculated by the Census of Agriculture including bearing and nonbearing acreage.

Table 3.2: Correlation Matrix of Population, Acreage, Availability, and Inflation-Adjusted Prices and Income[5]

	PECSALALL	PECSALIM	PECSALNS	RPECPRALL	RPECPRIMP	RPCPRNS
PECSALALL	1	0.63	0.83	-0.59	-0.54	-0.41
PECSALIM		1	0.08	-0.49	-0.65	-0.53
PECSALNS			1	-0.39	-0.22	-0.14
RPECPRALL				1	0.94	0.93
RPECPRIMP					1	0.93
RPCPRNS						1
RALMPR						

	RALMPR	RWALPR	BEARACR	AVAIL	RDISPINC	TXPOP
PECSALALL	-0.10	-0.30	0.27	0.85	0.27	0.27
PECSALIM	-0.07	-0.46	0.75	0.23	0.72	0.73
PECSALNS	-0.07	-0.05	-0.19	0.93	-0.18	-0.19
RPECPRALL	0.15	0.48	-0.45	-0.34	-0.44	-0.46
RPECPRIMP	0.18	0.55	-0.64	-0.22	-0.62	-0.64
RPCPRNS	0.11	0.52	-0.59	-0.09	-0.53	-0.57
RALMPR	1	0.62	-0.07	-0.10	-0.21	-0.19
RWALPR		1	-0.49	-0.06	-0.58	-0.60
BEARACR			1	-0.22	0.90	0.94
AVAIL				1	-0.15	-0.17
RDISPINC					1	0.99
TXPOP						1

[5] See Table 4.2 for variable nomenclature and descriptions

(0.99) between the two variables. The empirical analysis will test to find which of the two variables, if either, best explains pecan sales in the empirical model.

Hypotheses and Testing

The use of a multiple linear regression to perform the analysis on the effectiveness of Texas Pecan Board promotion in shifting demand for Texas pecans requires a number of hypothesis tests, some of which have already been discussed. Student's t-test will be used to test the null hypothesis that a parameter, such as the promotion coefficient, is equal to zero. Testing will also be used to search for the presence of multicollinearity using the variance inflation factor (VIF), and any other suspected violations of the OLS assumptions. As stated previously, the VIF measures the degree to which an exogenous variable is a linear combination of other independent variables. By rule of thumb, values greater than 5 or 10 tend to be the accepted critical values. This study will use 5 as a conservative measure to determine if two variables are collinear. Multicollinearity will be specifically addressed due to the high correlation and theoretical similarity between the prices of improved varieties and of native and seedling varieties of pecans (Table 3.2). The problem of multicollinearity will be further addressed during the specification and testing of the empirical model. As discussed previously, improved varieties will be tested separately from native varieties based on the hypothesis that promotion efforts have had a greater impact on improved varieties than native varieties.

An assumption of this research is that supply is perfectly elastic, indicating that there is no price response in this demand analysis. The next assumption is that the data used are accurate. The reliability of the results of this research is dependent on the accuracy of statistical hypothesis involved with the ordinary least squares and seemingly unrelated regression techniques and return-on-investment analysis. With regard to data, an additional assumption underpinning this research is that "utilized production" data is equivalent to "sales" as specified by the USDA. Utilized production is defined by the USDA as that which is consumed, used at home, or placed in ending inventory. The amount placed in ending inventory each year must be relatively small and constant for sales and changes in sales to be equivalent to utilized production and changes in utilized production. Furthermore, the supposition that Texas Pecan Board expenditures as promotion expenditures were correctly classified must be accepted.

Hypotheses that will be tested are the significance of promotion expenditures in shifting out demand; the difference in impact of promotion on improved versus native pecan varieties, and the significance or insignificance of disposable income, population of Texas, total bearing acreage, and prices of walnuts and almonds in determining demand. An additional hypothesis that will be tested is that because improved varieties are primarily consumed at the household level, and because the Texas Pecan Board tends to promote household consumption, the Texas Pecan Checkoff Program may have had a greater impact on sales of improved varieties than native varieties. The statistical significance of the structural change in the pecan industry from native to improved varieties will also be tested for in the separate demand equations with a structural binary variable. Finally, the record high sales year for improve varieties in 2001 followed by a record low year in 2002 will be tested for statistical significance in the disaggregated, improved demand equation.

CHAPTER IV

EMPIRICAL MODELS, ANALYSIS, AND RESULTS

As discussed throughout the preceding chapters, this research evaluates the effectiveness of the Texas pecan checkoff program in shifting the demand for Texas pecans. This chapter undertakes three empirical investigations:

1. The statistical measurement of the effects of Texas Pecan Board's (TPB) promotion expenditures on sales of all Texas pecans (improved and native varieties combined),
2. The statistical measurement of the differential effects of Texas Pecan Board promotion expenditures on improved and native pecans, and
3. The estimation of the return on investment from promotion of Texas pecan sales in terms of a benefit-cost ratio.

Determining the Demand Equation for All Pecans

The first objective is achieved using the ordinary least squares (OLS) regression to test for statistical significance between promotion expenditures and sales. As discussed in the previous chapter, the variables that this analysis will consider include Texas Pecan Board promotion expenditures, all pecan (improved and native combined) prices, almond and walnut prices, disposable income, availability, and a dummy variable to represent the structural change in the market as producers began switching from native to improved pecans in about 1977.

Following the conceptual model defined in Chapter III for analyzing the demand for all pecans, the model is specified as:

$$(4.1) \qquad Y = f(PROM_{t-j}, PR^{P}, PR^{A}, PR^{W}, AV, DI, S; \lambda_0, \lambda_1, \lambda_2, \lambda_3, \lambda_4, \lambda_5, \lambda_6)$$

where Y is sales of all pecans, $PROM_{t-j}$ is promotion expenditures with *j* lags, PR^{P} is the real price of all pecans (weighted average of improved and native), PR^{A} is the real price of almonds, PR^{W} is the real price of walnuts, AV represents availability of pecans using yield as a proxy, *DI* is U.S. disposable income, *S* is a binary variable representing a structural change in the industry, and $\lambda_0, \lambda_1, \lambda_2, \lambda_3, \lambda_4, \lambda_5, \lambda_6$ are the estimated coefficients for y-intercept, promotion, pecan price, almond price, walnut price, availability, and U.S. disposable income, respectively.

Equation (4.1) is estimated using a log-log transformation[6] of the data in order to convert the coefficients into elasticities, assuming constant elasticities. After estimating equation (4.1), almond prices, walnut prices, and U.S. disposable income were not found to be statistically significant at the 95% confidence level using Student's t-statistic. The modified equation estimated with a log-log transformation, after removing statistically insignificant variables, was defined as:

$$(4.2) \qquad \ln(Y) = f(\sqrt{PROM_{t-j}}, \ln(PR^{P}), \ln(AV), S; \lambda_0, \lambda_1, \lambda_2, \lambda_3, \lambda_4)$$

where λ_2 and λ_3 are the elasticities of price for all pecans and availability, respectively.

[6] The log-log transformation uses the natural log ($\log_e$)

Statistically Significant Variables in the Demand for All Texas Pecans

As discussed in the previous chapter, different numbers of lags of promotion expenditures by the Texas Pecan Board will be tested using the Akaike Information Criterion (AIC). The Texas Pecan Board promotion data contains zeros as data points from 1971 through 1998, so the logarithm of the promotion variable (*PROM*) cannot be calculated. However, to maintain a diminishing marginal returns relationship between *RPECPROME* and *PECSALALL* and to allow easy conversion of the estimated coefficient into an elasticity, the square root of the promotion data will be used.

As discussed in the previous chapter, the benefit-cost ratio will require the calculation of the elasticity of promotion. The square-root of promotion coefficient will be converted into a short-run elasticity using the definition of the elasticity as follows:

$$(4.3) \qquad e_t^{PROM} = \frac{\partial \hat{Y}}{\partial PROM_t}\left(\frac{PROM_t}{\hat{Y}}\right)$$

$$(4.4) \qquad e^{PROM} = \frac{\hat{\lambda}^{PROM}}{2}\sqrt{\frac{\sum_{t=1}^{n-j} PROM_t}{n}}$$

where e^{PROM} is the Texas Pecan Board promotion elasticity of demand, $\hat{\lambda}^{PROM}$ is the estimated parameter from the OLS output, n is number of observations, $\hat{Y}$ is the estimated demand equation (4.2), and $\sqrt{\frac{\sum_{t=1}^{n-j} PROM_t}{n}}$ is the mean promotion expenditure from 1971 to 2006.

The price of all pecans received by growers (PR^P) was adjusted for inflation using the consumer price index for all products with base years 1982-1984=100. In accordance with demand theory, this variable should have a negative relationship with demand.

Availability of pecans (AV) is of particular interest in the demand for pecans because of the high variations in yield each year. Because Texas production has varied by as much as 80 million pounds from year to year, total consumption is limited by the quantity of pecans that is available for sale. As discussed in the previous chapter, the yield of all pecans is used as the proxy for availability.

As mentioned in the previous chapter, there has been a transition in the pecan industry from producing native pecans to improved varieties which requires the use of a structural binary variable (*S*). This is because there has been an increased consumer demand for improved pecans with high quality characteristics including high meat content which began around 1977.

Empirical Results from All Pecans Demand Equation

As previously mentioned, the modified equation (4.2) will be re-estimated using a variety of different lag structures in order to maximize goodness of fit and model parsimony as determined by the Akaike Information Criterion (AIC). There were limitations on the number of lags and lag structures that could be used because the data were crop year (12-month) series, and the Texas Pecan Board has only been promoting pecans since 1999. After testing both a polynomial distributed lag and geometric lag, it was determined that a single, non-weighted lag of promotion provided the most parsimonious results according to the AIC (Table 4.1), and also maximized the coefficient of determination.

The results from estimating equation (4.2) as presented in Table 4.1 displayed serial correlation issues as seen with a Durbin-Watson of 1.033, implying that the residuals are not randomly distributed. Definitions of variables as well as nomenclature used throughout this discussion are provided in Table 4.2. The error term correlation may be due to some non-random information that influences pecan sales not accounted for in equation (4.2). To improve the accuracy of the predicted values and correct for the serial correlation, an autoregressive error correction model (ECM) will be estimated in place of the ordinary least squares regression model using the Yule-Walker method. This model uses lags of the error term to correct the estimates for autocorrelation and create a random normally distributed error term η_t:

$$\ln(Y) = \lambda_0 + \lambda_1 \sqrt{PROM_{t-1}} + \lambda_2 \ln\left(PR_t^P\right) + \lambda_3 \ln\left(AV_t\right) + \lambda_4 S_t + \varepsilon_t \tag{4.5}$$

$$\varepsilon_t = -\varphi_1 \varepsilon_{t-1} + \eta_t \tag{4.6}$$

$$\eta_t = N\left(0, \sigma^2\right) \tag{4.7}$$

Equation (4.5) is the demand equation for all pecans with error term (ε_t). The error term (ε_t) is not randomly distributed suggesting that there is a nonrandom component ($-\varphi_1 \varepsilon_{t-1} + \eta_t$) to the error term. Accounting for this nonrandom component through lags of the error term yields a normally distributed random disturbance term (η_t).

Table 4.1: The OLS Results for the Demand of All Pecans without Correction for Autocorrelation

The AUTOREG Procedure

Dependent Variable LOGPECSALAL

Ordinary Least Squares Estimates

SSE	0.20407287	DFE	30
MSE	0.00680	Root MSE	0.08248
SBC	-62.95948	AIC	-70.736221
Regress R-Square	0.9783	Total R-Square	0.9783
Durbin-Watson	1.0330	Pr < DW	0.0002
Pr > DW	0.9998		

NOTE: Pr<DW is the p-value for testing positive autocorrelation, and Pr>DW is the p-value for testing negative autocorrelation.

Variable	DF	Estimate	Standard Error	t Value	Approx Pr > |t|
Intercept	1	5.1975	0.2344	22.18	<.0001
LOGRPECPRALL	1	-0.002453	0.000797	-3.08	0.0044
LAGSQRTRPECPROME	1	0.000688	0.000156	4.42	0.0001
LOGAVAIL	1	1.0025	0.0347	28.88	<.0001
STRUCT	1	0.4800	0.0497	-9.66	<.0001

Estimates of Autocorrelations

```
Lag    Covariance     Correlation    -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1

  0      0.00583       1.000000    |                    |********************|
  1      0.00272       0.466418    |                    |*********           |
  2      0.00264       0.453572    |                    |*********           |
  3      0.00155       0.265088    |                    |*****               |
  4      0.00109       0.186195    |                    |****                |
  5     0.000797       0.136651    |                    |***                 |
```

Backward Elimination of Autoregressive Terms

Lag	Estimate	t Value	Pr > |t|
5	-0.022541	-0.11	0.9111
3	0.019061	0.09	0.9272
4	0.046761	0.26	0.7995
2	-0.301648	-1.67	0.1052

Preliminary MSE 0.00456

See Table 4.2 for Variable Nomenclature and Descriptions

Table 4.2: Variable Nomenclature and Definitions

Variable	Symbol	Definition
ADDSALES	*ADS*	Additional sales of improved pecans generated from Texas Pecan Board promotion expenditures, lbs
ANOM	AD	Binary variable representing a record high sales followed by record low sales
AVAIL	*AV*	Availability of pecans using the proxy yield, lbs/acre
DISPINC	*DI*	Disposable personal income of United States measured in dollars, $
LAGPECSALIMP	Y^i_{t-1}	Lag of sales for improved varieties, thousand lbs
LAGPECSALNS	Y^n_{t-1}	Lag of sales for native varieties, thousand lbs
PECPRIM	PR^N	Nominal average Texas improved pecan price received by growers, cents/lb
PECSALALL	Y	Texas sales for both improved and native pecan varieties, thousand lbs
PECSALIMP	Y^i	Texas sales of improved pecan varieties, thousand lbs
PECSALNS	Y^*	Texas sales of native pecan varieties, thousand lbs
PROME	$PROM^N$	Nominal Texas Pecan Board promotion and advertising expenditures, $
RPECPROME	$PROM$	Real Texas Pecan Board promotion and advertising expenditures, $
RPECPRALL	PR_P	Real average Texas pecan price received by growers, cents/lb
RPECPRIM	PR^i	Real average Texas improved pecan price received by growers, cents/lb
RPECPRNS	PR^n	Real average Texas native/seedling pecan price received by growers, cents/lb
RALMPR	PR_A	Real average almond price received by growers, cents/lb
REVENUES	R_t	Additional revenues generated from Texas Pecan Board promotion expenditures, $
RWALPR	PR_W	Real average walnut price received by growers, cents/lb
STRUCT	S	Binary variable representing a structural change in the pecan industry from 1976-2006

The analysis utilizes the backwards elimination (BACKSTEP) option in SAS to remove insignificant autoregressive parameters starting in order of least significance. Backwards elimination concludes that one lag of the error term is most appropriate for removing serial correlation (Table 4.3). The error correction model improves the results significantly, increasing the Durbin-Watson (DW) to 1.5797 (Table 4.3). Using a five percent significance for the Durbin-Watson test with n=36 observations and k=4, the upper and lower bounds are $D_U = 1.73$ and $D_L = 1.24$, respectively. The upper and lower bounds can be used to conclude that the results are indeterminate ($1.24 < DW = 1.5797 < 1.73$). However, according the Pr < DW output, the DW is significant at the ten percent level at which the null hypothesis that positive autocorrelation exists is rejected. The coefficient of determination for the error corrected model is 0.9856, indicating that the model accounts for a high proportion of the variability in the data (Figure 4.1).

The first question of whether or not promotion has had a significant impact on expanding the demand for pecans is answered using the results provided in Table 4.3. The p-value for promotion is 0.0051 implying that promotion is highly significant at the 99% level. Using equation (4.3), the short-run promotion elasticity of demand (E_{RPROME}) is calculated as 0.03114 meaning that doubling promotion expenditures (a 100% increase) will lead to approximately a 3.1% increase in pecan sales, which is consistent with the findings for other commodity promotion programs (Williams, Capps, and Palma 2007). The results in Table 4.3 coincide with theoretical expectations. The variable STRUCT, a binary variable accounting for structural change during the period

Table 4.3: The OLS Results Using an Autoregressive Error Correction Model

The AUTOREG Procedure

Estimates of Autoregressive Parameters

LAG	Coefficient	Standard Error	t Value
1	-0.466418	0.164259	-2.84

Yule-Walker Estimates

SSE	0.13570295	DFE	29
MSE	0.00468	Root MSE	0.06841
SBC	-73.439121	AIC	-82.77121
Regress R-Square	0.9913	Total R-Square	0.9856
Durbin-Watson	1.5797	Pr < DW	0.0860
Pr > DW	0.9140		

NOTE: Pr<DW is the p-value for testing positive autocorrelation, and Pr>DW is the p-value for testing negative autocorrelation.

Variable	DF	Estimate	Standard Error	t Value	Approx Pr > |t|
Intercept	1	5.2593	0.1819	28.91	<.0001
LOGRPECPRALL	1	-0.001901	0.000718	-2.65	0.0129
LAGSQRTRPECPROME	1	0.000564	0.000186	3.03	0.0051
LOGAVAIL	1	0.9847	0.0247	39.93	<.0001
STRUCT	1	0.4095	0.0556	-7.36	<.0001

See Table 4.2 for Variable Nomenclature and Descriptions

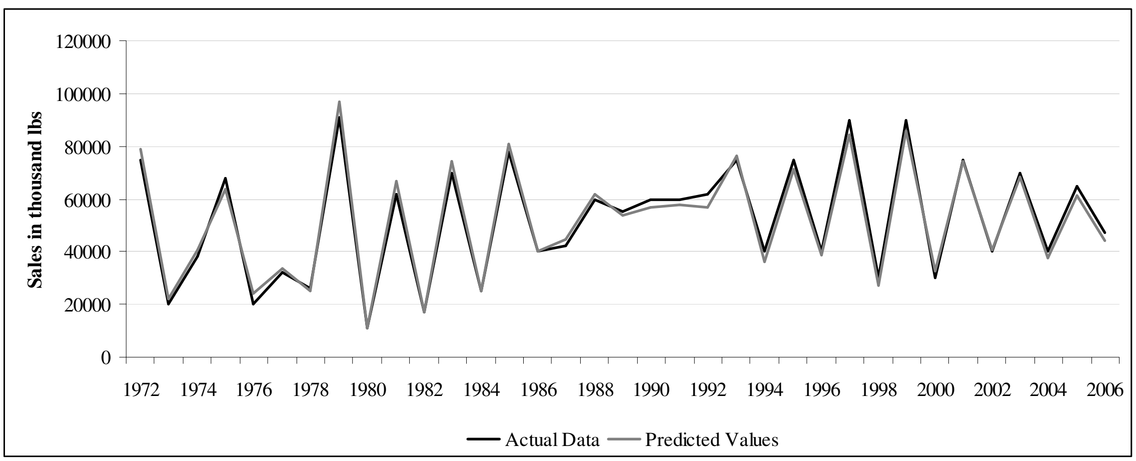

Figure 4.1: Actual Data Compared to Predicted Values Using ECM

of time prior to the industry transition from native to improved pecans (1971-1975), has a coefficient of 0.4095 meaning that from 1976-2006, the model underestimated pecan sales due to the structural changes in the industry. The own-price elasticity of demand for Texas pecans is estimated to be -0.001901 implying a highly price inelastic demand for Texas pecans. Combined with an availability elasticity of 0.9847, the low estimated price elasticity implies that Texas pecan sales are more responsive to changes in availability than to price changes.

The highly price inelastic demand for pecans is the first indication that econometric problems may exist in measuring native and improved varieties in a single, aggregate demand equation. One reason this issue arises is because the improved and native varieties are substitutes. However, using a weighted average of the prices of the two varieties in the aggregate demand equation forces native and improved varieties to be complements. For example, increases in the price of improved pecans should decrease sales of improved pecans but increase the sales of native pecans. However, as a component of an aggregate weighted pecan price, an increase in the price of improved pecans increases the weighted average price and reduces sales for all pecans, both native and improved. This offsetting effect may result in the highly price-inelastic estimated effect of the weighted average price on aggregate sales of pecans. To resolve this problem, equation (4.2) can be disaggregated into separate demand equations for improved and native pecans. This is done using the SUR to estimate the separate demand equation.

Estimating the Demand for Improved and Native Pecans Separately Using SUR

Texas Pecan Board promotion expenditures to promote pecan sales through festivals and conferences, advertisements on the radio, recipes at grocery stores, etc. focus primarily on household consumption. Pecans purchased by households are typically improved varieties. Native pecans, on the other hand, are purchased primarily for use in the production of candies, baking goods, and other food products (Worley 1994). Therefore, as discussed throughout the preceding chapters, it is hypothesized that the Texas Pecan Board Checkoff Program may have had a different impact on sales of improved pecan varieties compared to those of native pecans.

Separating the two categories of pecans into separate demand equations achieves the second objective. The parameters of these two equations can be examined separately using the seemingly unrelated regression (SUR) because of the theoretical similarity between the two equations. The SUR estimator will be utilized in place of the OLS because cross-equation error correlation may exist between the two equations. If cross-equation error correlation does not exist, the SUR estimates will be consistent with OLS estimates.

Following the conceptual models defined in Chapter III, the two demand equations that will be estimated are:

(4.8) $$Y_t^i = f(PR_t^i, PR_t^A, PR_t^W, PROM_{t-1}, Y_{t-1}^i, AV_t, S_t, AD_t, DI_t)$$

(4.9) $$Y_t^n = f(PR_t^n, PR_t^A, PR_t^W, PROM_{t-1}, Y_{t-1}^n, AV_t, DI_t)$$

where the superscript *i* denotes improved variety-specific parameters and the superscript *n* represents native-specific parameters for *t* years 1971-2006. The additional binary variable (*AD*) represents the largest change in Texas improved pecan production from one year to the next in recorded history (2001-2002). Equations (4.8) and (4.9) were estimated using a log-log transformation of the data in order to convert the coefficients into elasticities, assuming constant elasticities. After estimating equations (4.8) and (4.9), almond prices, walnut prices, and U.S. disposable income were not found to be statistically significant at the 95% confidence level using Student's t-statistic.

As discussed in the previous chapter, a high correlation between native and improved pecan prices (0.93) suggests that each price may be a linear combination of the other. Thus, both improved and native prices were not included in each demand equation during the specification of the conceptual models. After testing for multicollinearity using the variance inflation factor (VIF), the hypothesis test failed to reject the null hypothesis that multicollinearity is present at a critical value of VIF=5 and reported VIF statistics of 11.39 and 9.88 for improved and native pecan prices, respectively. Therefore, as hypothesized in the previous chapter, improved and native pecan prices are highly collinear, and both should not be included in each of the demand equations (4.10 and 4.11).

Empirical Results from Estimating the Improved and Native Demand Equations

The modified equations estimated with log-log transformations after removing statistically insignificant variables are defined as:

$$(4.10)\qquad Y_t^i = \lambda_0^i + \lambda_1^i PR_t^i + \lambda_2^i \sqrt{PROM_{t-1}} + \lambda_3^i Y_{t-1}^i + \lambda_4^i AV_t + \lambda_5^i S_t + \lambda_6^i AD_t + \omega_t^i$$

$$(4.11)\qquad Y_t^n = \lambda_0^n + \lambda_1^n PR_t^n + \lambda_2^n \sqrt{PROM_{t-1}} + \lambda_3^n Y_{t-1}^n + \lambda_4^n AV_t + \omega_t^n$$

where Y_t^k, PR_t^k, Y_{t-1}^k, and AV_t are all estimated with the natural log transformation for k=i,n, and ω_t^i and ω_t^n are the residuals for the improved and native pecan demand equations, respectively. The OLS results from the improved and native demand equations (4.10 and 4.11) can be seen in Table 4.4 and Table 4.5, respectively. However, to determine if SUR is needed to increase the efficiency of the statistical results, the covariance of the error terms is calculated in Table 4.6 which displays a cross-equation error correlation of -0.81576 suggesting highly correlated error terms. The SUR corrects for error correlation and provides more efficient estimates of the variable parameters than the OLS results. These results also display the SUR system weighted R^2 of 0.9714, which is higher than the R^2 for the separately estimated improved and native equations of 0.9005 and 0.9125, respectively.

The results for the two-equation SUR model are provided in Table 4.7. The most interesting result is the significance of promotion at the 10% level (p-value=0.0531) in the improved equation and the insignificance of promotion in the native equation (p-value=0.7423) providing evidence in favor of the hypothesis that promotion has had a positive impact on the demand for improved varieties and no effect on the demand for native pecans. The short-run promotion elasticity of demand for improved varieties can be calculated using equation (4.2) as 0.04422. This elasticity can be interpreted as a 100% increase in promotion expenditures will lead to an approximate 4.2% increase in sales of improved pecans.

Correcting for cross-equation error correlation between ω_t^i and ω_t^n, the SUR increases efficiency in the estimates, adjusting the estimated short-run own-price

Table 4.4: The OLS Results for the Demand of Improved Pecan Varieties

The SYSLIN Procedure
Ordinary Least Squares Estimation
Dependent Variable LOGPECSALIM

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	9.193885	1.532314	42.25	<.0001
Error	28	1.015435	0.036266		
Corrected Total	34	10.20932			

Root MSE	0.19044	R-Square	0.90054
Dependent Mean	10.04172	Adj R-Sq	0.87923
Coeff Var	1.89644		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	2.827543	1.520433	1.86	0.0735
LOGRPECPRIMP	1	−0.25801	0.156180	−1.65	0.1097
LAGSQRTRPECPROME	1	0.000980	0.000382	2.57	0.0159
LAGLOGPECSALIM	1	0.465264	0.077029	6.04	<.0001
LOGAVAIL	1	0.654181	0.081896	7.99	<.0001
STRUCT	1	0.55847	0.135781	−4.11	0.0003
ANOM	1	−0.66900	0.210151	−3.18	0.0036

See Table 4.2 for Variable Nomenclature and Descriptions

Table 4.5: The OLS for the Demand of Native Pecan Varieties

The SYSLIN Procedure
Ordinary Least Squares Estimation
Dependent Variable LOGPECSALNS

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	20.11841	5.029602	78.28	<.0001
Error	30	1.927568	0.064252		
Corrected Total	34	22.04598			

Root MSE	0.25348	R-Square	0.91257
Dependent Mean	9.88675	Adj R-Sq	0.90091
Coeff Var	2.56384		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	3.961765	1.241824	3.19	0.0033
LOGRPECPRNS	1	0.023492	0.125535	0.19	0.8528
LAGSQRTRPECPROME	1	0.000053	0.000476	0.11	0.9121
LAGLOGPECSALNS	1	−0.17036	0.072008	−2.37	0.0246
LOGAVAIL	1	1.312499	0.109719	11.96	<.0001

NOTE: Convergence criterion met at iteration 8.

See Table 4.2 for Variable Nomenclature and Descriptions

Table 4.6: Cross Model Covariance and Correlation Statistics for the Error Terms

The SYSLIN Procedure
Iterative Seemingly Unrelated Regression Estimation

Cross Model Covariance

	LOGPECSALIM	LOGPECSALNS
LOGPECSALIM	0.042233	-.044144
LOGPECSALNS	-.044144	0.069336

Cross Model Correlation

	LOGPECSALIM	LOGPECSALNS
LOGPECSALIM	1.00000	-0.81576
LOGPECSALNS	-0.81576	1.00000

Cross Model Inverse Correlation

	LOGPECSALIM	LOGPECSALNS
LOGPECSALIM	2.98927	2.43853
LOGPECSALNS	2.43853	2.98927

Cross Model Inverse Covariance

	LOGPECSALIM	LOGPECSALNS
LOGPECSALIM	70.7811	45.0635
LOGPECSALNS	45.0635	43.1126

System Weighted MSE	1.0012
Degrees of freedom	58
System Weighted R-Square	0.9714

See Table 4.2 for Variable Nomenclature and Descriptions

Table 4.7: SUR Output for Improved and Native Pecan Demand Equations

The SYSLIN Procedure
Iterative Seemingly Unrelated Regression Estimation

Dependent Variable LOGPECSALIM

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	3.891423	1.174182	3.31	0.0025
LOGRPECPRIMP (PRi)	1	−0.32312	0.140502	−2.30	0.0291
LAGSQRTRPECPROME (PROMt−1)	1	0.000801	0.000396	2.02	0.0531
LAGLOGPECSALIM (Yt−1)	1	0.392642	0.051400	7.64	<.0001
LOGAVAIL (AV)	1	0.646930	0.079014	8.19	<.0001
STRUCT (S)	1	0.68397	0.095997	−7.12	<.0001
ANOM (AD)	1	−0.28401	0.131801	−2.15	0.0399

Durbin-Watson	2.51789
Number of Observations	35
First-Order Autocorrelation	−0.29533

Dependent Variable LOGPECSALNS

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	2.218923	0.988572	2.24	0.0323
LOGRPECPRNS (PRn)	1	0.103086	0.118872	0.87	0.3927
LAGSQRTRPECPROME (PROMt−1)	1	0.000163	0.000492	0.33	0.7423
LAGLOGPECSALNS (Y*t−1)	1	−0.08370	0.049658	−1.69	0.1023
LOGAVAIL (AV)	1	1.411479	0.100765	14.01	<.0001

Durbin-Watson	1.831096
Number of Observations	35
First-Order Autocorrelation	0.063612

See Table 4.2 for Variable Nomenclature and Descriptions

elasticity of demand for improved varieties from -0.258 to -0.3231. Following Labys (1973), a long-run elasticity of price (e_L) can also be calculated by dividing the short-run elasticity (e_S) by the elasticity of adjustment (δ) which is calculated as one minus the estimated coefficient for the lagged dependent variable (λ_{LD}):

(4.12) $$\delta = 1 - \lambda_{LD}$$

(4.13) $$e_L = \frac{e_S}{\delta}$$

The elasticity of adjustment describes the speed of demand adjustment and is calculated as 0.607 using equation (4.12) suggesting that only approximately 60% of demand adjusts to the equilibrium demand within a single period. The elasticity of adjustment provides an explanation for why the estimated own-price elasticity of demand for pecans is significantly lower than the own-price elasticity of demand for pecans measured by Onunkwo and Epperson (2000), because the dynamic demand response suggests that demand only adjusts a fraction of the distance toward the demand equilibrium rather than a complete adjustment in a single period. Using equation (4.13), the long-run own-price elasticity of demand is calculated as -0.3363. The estimated price of improved pecans is significant at the 0.029 level when using the SUR estimator compared to the 0.11 level before correcting for cross-equation correlation of the error terms.

The two equations can be compared in order to understand the difference in demand for these two competing classifications of pecans. One interesting difference between the two demand equations is the significance of the price of improved pecans in determining the demand for improved pecans compared to the insignificance of the price of native pecans in explaining the sales of native pecans. The insignificance of price in the native model does not necessarily mean that consumers do not consider price when making their purchasing decisions. Rather, the results suggest that changes in price do not result in large changes in purchases of native pecans and that purchases are more sensitive to changes in the availability of pecans for sale than to changes in the price of native pecans.

Availability is highly significant (<0.0001) for both improved and native varieties because the highly variable availability of pecans for sale from year to year acts as a constraint to pecan purchases in off years and allows greater market responsiveness in on years. In other words, consumers can only purchase as much during a year as is available. As discussed in Chapter II, native varieties are more susceptible to fluctuating yields than improved varieties. Thus, not surprisingly, the estimated coefficient for the availability of pecans is much higher for native/seedling varieties (1.4114) than it is for improved varieties (0.6469).

The transition in the market from consumption of native pecans to consumption of improved pecans can be seen in the results as well. The lagged dependent variable in each model indicates the trends in the sales of the two pecan varieties. As producers are switching from native to improved varieties, the coefficient for lagged improved sales is positive whereas it is negative for lagged native sales. As discussed in the previous chapter, the offsetting trends of the lagged dependent variables are representative of changing consumer demand. Consumers are demanding more improved varieties and less native varieties. However, this change in demand does not occur instantaneously.

Rather consumer demand changes dynamically over a given period of time due to ingrained consumer habits. The lagged consumer response, defined as habit persistence, is the reason for offsetting trends between the lagged sales of improved and native pecan varieties. The lags for improved and native sales are significant at the 1% and 15% levels, respectively.

Summary of Empirical Analyses and Introduction to Benefit-Cost Analysis

The previous results from the OLS regression for all pecans imply that pecan promotion has effectively shifted demand outward (to the right) for pecans in general, thus increasing the quantity of total pecan sold. The SUR results indicate that improved varieties are impacted by advertising, while promotion is not a statistically significant determinant of changes in native variety pecan sales.

As mentioned in the previous chapter, even if a promotion program is found to be significant in shifting out demand for pecans, it does not necessarily mean that the revenues generated by the increased demand outweigh the cost of promotion. The BCR measures additional revenues generated for every dollar spent on promotion. As the SUR model in Table 4.7 suggests that promotion expenditures did not affect sales contemporaneously, the lagged promotion expenditures will be used to compute the benefit-cost statistics. The promotion program is defined to be effective if the computed BCR is greater than one and is defined to be ineffective otherwise because a net revenue BCR less than one suggests that less than one dollar in additional revenues is generated per dollar spent on promotion. On the other hand, a net revenue BCR greater than one suggests that more than one dollar is generated per dollar spent on promotion, thus there is a positive return on the investment in promotion. The benefit-cost ratio will be calculated using the promotion elasticity of demand. A Sales BCR will also be calculated to compute the additional sales in pounds generated per dollar spent on advertising.

Recall the discussion on the BCR in Chapter III. As there was only one lag used in our estimation, the BCR over all years of promotion can be calculated using the elasticity of promotion (e_t^{PROM}). Instead of using the average of promotion expenditures to calculate an overall elasticity and applying it to each time period as done in equation (4.3), equation (4.14) calculates the elasticity for every year given the effective promotion[7] for that year:

(4.14) $$e_t^{PROM} = \frac{\partial \hat{Y}}{\partial PROM_{t-1}} \left(\frac{PROM_{t-1}}{\hat{Y}} \right) = \frac{\hat{\lambda}_2^{\,i}}{2} \sqrt{PROM_{t-1}}$$

where $\hat{\lambda}_2^{\,i}$ is the estimated promotion coefficient from the SUR regression for the improved pecan demand equation. The calculation of the elasticity of promotion uses promotion expenditures after adjusting for inflation. This is because the coefficient ($\hat{\lambda}_2^{\,i}$) in the elasticity computation was estimated in the SUR analysis using real promotion expenditures rather than nominal. Using these elasticities, the additional sales (*ADS*) in a given period can be calculated as:

(4.15) $$ADS_t = e_t^{PROM} \times Y_t^i$$

[7] Promotion was found to be effective when using one lag of promotion

where Y_t^i is the actual quantity of improved pecans sold. Summing equation (4.15) over all *n-1* years of effective promotion yields the total additional sales (*ADS*) generated from the promotion expenditures:

(4.16) $$ADS = \sum_{t=1}^{n-1} e_t^{PROM} \times Y_t^i$$

The additional revenues can be calculated for a given year by multiplying *ADS* by the nominal price of improved pecans (PR_t^N) for a specific year:

(4.17) $$R_t = e_t^{PROM} \times Y_t \times PR_t^N = ADS_t \times PR_t^N$$

Equation (4.17) can be summed over all *n-1* years, which are the years that promotion has generated observed benefits, yielding the total additional revenues (*R*) generated from the promotion expenditures:

(4.18) $$R = \sum_{t=1}^{n-1} e_t^{PROM} \times Y_t \times PR_t^N = \sum_{t=1}^{n-1} ADS_t \times PR_t^N$$

Building upon equation (3.19) in Chapter III, benefits in terms of additional revenues generated from promotion can be computed by as a revenue benefit-cost ratio (*PBCR*):

(4.19) $$PBCR = \frac{\sum_{t=1}^{n} R_t}{\sum_{t=1}^{n-1} PROM_t^N} = \frac{\sum_{t=1}^{n} \left(e_t^{PROM} \times Y_t \times PR_t^N\right)}{\sum_{t=1}^{n-1} PROM_t^N}$$

where $\sum_{t=1}^{n} R_t$ are the total additional revenues generated from the promotion expenditures; Y_t is the actual sales in period *t*; PR_t^N is the nominal price of improved pecans received by growers in period *t*, and $\sum_{t=1}^{n-1} PROM_t^N$ is the total cost of the promotion program over all *n-1* years. Netting the cost of promotion out of the BCR by subtracting it from total additional revenues provides the net revenue BCR which is calculated as:

$$BCR = \frac{\sum_{t=1}^{n}\left(e_t^{PROM} \times Y_t \times PR_t^N\right)}{\sum_{t=1}^{n-1} PROM_t^N} - 1 \tag{4.20}$$

Promotion was found to have a lagged effect on sales of pecans. Therefore, sales in the last observed year (2006/2007) were not included in the summation of promotion expenditures because the effects from the 2006/2007 crop year advertisements have not yet been experienced. The sum of benefits over all *n-1* years are referred to "experienced" benefits, and the promotion expenditures that have yielded benefits are referred to as "effective" promotion expenditures.

The additional revenues generated from the Texas Pecan Board promotion expenditures can be discounted back to present value in order to calculate a discounted net revenue benefit-cost ratio (discounted BCR). The discounted revenues are calculated as:

$$R^D = \sum_{t=0}^{T} R_t (1+i)^T \tag{4.21}$$

where R^D is the discounted revenues; R_t is the additional revenues generated from the Texas Pecan Board promotion program in period *t*; *T* is the duration of the promotion program in years, and *i* is the interest rate. To compute the present value of the additional revenues, the investment rate (*i*) in equation (4.21) must be identified. Instead of using an arbitrary rate, other reasonable alternative investments can be used. As discussed by Williams (1999), the choice of an alternative interest rate in critical in determining the discounted revenues. Following Williams (1999), the 30-day U.S. Treasury bill (T-bill) rate is used because it represents a conservative, alternative investment for the Texas Pecan Board. The discounted revenue is calculated using the T-bill interest rates for every given year:

(4.22) $$R^D = \sum_{t=1}^{T} \left[\frac{R_t}{\prod_{j=1}^{t} \left(1 + i_j\right)} \right]$$

where i_j is the 30-day Treasury bill interest rate in year *j*.

The promotion expenditures in this analysis effectively generated revenues for seven years from 2000-2006. Therefore, the discounted benefits is calculated by setting *T* equal to seven and discounting each realized additional revenue back to present value in the initial period (*t*=1). The discounted gross benefits will be calculated by summing all discounting additional revenues generated (R_t) over all *t* years of recognized benefits:

(4.23) $$R^D = \frac{R_1}{(1 + i_1)} + \frac{R_2}{(1 + i_1)(1 + i_2)} + \cdots + \frac{R_7}{(1 + i_1)(1 + i_2)(1 + i_3)\cdots(1 + i_7)}$$

Using the summation of all discounted revenues, the discounted BCR (*DBCR*) is calculated as:

(4.24) $$DBCR = \frac{R^D}{C^N} - 1$$

where C^N is the total cost of the promotion program over $n-1$ years, and one is subtracted from the ratio of discounted revenues to total costs in order to remove the cost of promotion from the generated revenues to yield the additional revenues generated.

Promotion Effects on Sales of Texas Pecans

Equations (4.15), (4.16), (4.18) can be used to calculate the additional sales and additional industry revenues generated from promotion. These values will be used in the application of equations (4.19) and (4.20) in order to calculate benefit-cost ratios.

Applying equation (4.15), the average additional sales of improved pecans in Texas was calculated as 3.0 million pounds per year over the seven years of promotion effects. Applying equation (4.16) to all years of effective promotion, the total additional sales generated was over 21.5 million pounds. This amounts to over 29.4 million dollars in additional industry revenues over the seven years of effective promotion with an annual average of over 4.2 million dollars per year (equation 4.18).

Using the equations (4.19) and (4.20) and the elasticity, the revenue (PBCR) and net revenue benefit-cost ratios (BCR) for the Texas Pecan Board promotion program can be calculated for improved varieties. Using the results from the SUR model, the revenue BCR is calculated as 41.7. Netting the cost of promotion out of the revenue BCR yields a net revenue BCR for improved varieties of 40.7 (Table 4.8). This indicates that for every dollar spent on promotion by the Texas Pecan Board, approximately $40.7 is generated in additional revenue across the Texas pecan industry. To provide a different perspective on the effects of promotion on the Texas pecan industry, a Sales BCR is calculated as 30.5 lbs per promotion dollar. In other words, each dollar spent on promotion is estimated to have generated approximately 30.5 pounds of additional improved pecan sales over the 1999 to 2006 period of promotion by the Texas Pecan Board. Using the 30-day U.S. Treasury bill as an alternative investment, equation (4.22) was used to calculate a discount BCR of 35.4 (Table 4.8), which is lower than the net revenue BCR of 40.7.

The analysis suggests, however, that promotion expenditures did not have a statistically significant effect on sales of native pecans. The Texas Pecan Board focused on increasing the visibility of pecans for home consumption, and by doing so, may have inadvertently promoted sales of improved varieties and not sales of native varieties. This follows the original hypothesis because improved varieties tend to be used for home consumption, while native pecans tend to be used for food and candy production. Higher meat contents of improved varieties and greater shell-out ratios mean consumers of improved varieties get more food for their dollar. Greater resistance to diseases and insects means a higher proportion of the pecans will be high quality.

Finally, lower yield fluctuations mean consumers can expect the availability of the product and prices to be more consistent from year to year than is the case for native varieties. On average, native nuts are difficult to shell, small, and have low meat contents due to thick shells (Worley 1994). Native pecans are typically sold for production use in candies and pastries (Worley 1994). Thus, the Texas Pecan Board's promotion of pecans targeted household consumers who typically purchase improved varieties over native varieties (Worley 1994).

Table 4.8: Benefit-Cost Analysis of Texas Pecan Promotion, 2000/2001-2006/2007

	SUR Model[1]
	Improved Varieties
Additional Sales (lbs)	
Crop Year Average	3,076,360.41
Total	21,534,522.89
Average Price[2] **($/lb)**	1.31
Additional Revenue ($)	
Crop Year Average	4,200,136.34
Total	29,400,954.40
Promotion Expenditures ($)	
Crop Year Average	101,976.63
Effective Promotion Average	100,603.06
Total Expenditures	815,813.05
Total Effective Promotion Expenditures	704,221.40
Revenue BCR ($/$)	41.75
Net Revenue BCR ($/$)	40.75
Discount BCR ($/$)[3]	35.47
Sales BCR (lbs/$)	30.58

[1]This estimate measures the effects of promotion on improved pecans after accounting for cross-equation error correlation between native and improved pecan demand equations
[2]All dollar values are computed in nominal terms
[3]Discount BCR computed using the 30-day U.S. Treasury bill interest rate

Summary of Empirical Analysis

First, using ordinary least squares estimator (OLS), this study concludes that advertising expenditures by the Texas Pecan Board have effectively increased the demand for Texas pecans. Second, the study considered the possibility of differentiating effects of promotion on the two varieties of pecans: improved and native. To test for differential effects of promotion on native and improved varieties, the native and improved pecan demand equations were estimated separately. After finding cross-equation error correlation, the two demand equations were estimated using the seemingly unrelated regression (SUR), which increased efficiency in the estimated model parameters due to the native and improved demand equations being conceptually related through similar determinants of demand and their status as competing commodities. Estimating the native and improved demand equations separately with the SUR estimator indicated that promotion had increased sales of improved varieties and had not affected the sales of native varieties. The calculation of a benefit-cost ratio suggests that for every dollar spent on promotion, approximately $40.7 was generated in additional industry sales revenues. A Sales BCR was calculated as 30.5 indicating that every dollar spent on promotion by the Texas Pecan Board generates approximately 30.5 pounds of additional sales of improved pecans across the industry.

CHAPTER V

SUMMARY AND CONCLUSIONS

The pecan industry supplies a perishable, perennial commodity to a market relatively free of government intervention. Yields for pecans have a natural tendency to vary widely from year to year, a characteristic that is commonly referred to as the alternate-bearing nature of the pecan. Years of high production are referred to as "on years" and low production years as "off years." The two primary classifications of pecans are improved and native or seedling. Native varieties are those varieties that have not been altered through selection or controlled crossing, and typically produce smaller nuts and are more susceptible to the alternate-bearing yield fluctuations than improved varieties. Improved varieties are clones that have been grafted or budded in order to conserve desirable characteristics such as high meat content, low yield fluctuations, and resistance to diseases and insects.

The Texas Pecan Board was established in 1998 to administer the Texas Pecan Checkoff Program and is financed through a one-half cent per pound assessment on grower pecan sales. The Board spends the assessment collections on a variety of promotional activities in an attempt to expand demand for Texas pecans and increase the welfare of Texas pecan growers. These expenditures were categorized in Chapter II into different categories including media, festivals and conferences, website, and research.

Results from the Qualitative Analysis

This study presents a comprehensive evaluation of the economic effectiveness of the Texas Pecan Checkoff Program. The specific objectives of the research were:

1. Qualitatively analyze the U.S. and Texas pecan industries and the role of the Texas Pecan Checkoff Program as background to the statistical analysis of the program
2. Identify and statistically measure the effects of the main economic drivers of all Texas pecan sales compared to those of improved and native Texas pecan sales;
3. Statistically isolate the effects of the promotion of Texas pecan sales through the Texas Pecan Checkoff Program, and
4. Determine the return on the investment made on promotion of all Texas pecan sales as well as improved and native Texas pecans through the Texas Pecan Checkoff Program.

The first objective was achieved in Chapter I and Chapter II through a discussion and qualitative analysis of the Texas Pecan Checkoff Program and the characteristics of the U.S. and Texas pecan industries. Chapter II discussed the characteristics of the U.S. and Texas pecan industries including the prices of pecans and substitute goods such as almonds and walnuts, regional production characteristics, quality, and trade. The background that was developed on the Texas Pecan Checkoff Program and the U.S. and Texas pecan industries in Chapter II was important for defining the conceptual models and hypotheses to be tested in Chapter III. Among the principal conclusions flowing from the qualitative assessment in Chapter II were the following:

1. Improved and native pecans differ greatly physically and in use. Improved pecans are typically larger, more resistant to diseases and insects, and less susceptible to alternate-bearing yields than native pecans. Native varieties typically have higher oil contents, higher yield fluctuations, and produce smaller nuts than improved varieties. Nuts from improved varieties are used primarily for household consumption, while those from native varieties are primarily used for industrial food production in candies, pastries, and other foods.

2. More than 80% of the world's pecans are produced in the U.S. Pecans are produced throughout the southern U.S. from California to Georgia. The lead producing state is Georgia, followed closely by Texas and New Mexico. Harvesting seasons for pecans in the U.S. range from mid-September to late February. Texas has the longest marketing season from mid-September to late January, and represents 25% of total U.S. pecan production on average.

3. U.S. pecan exports have been increasing, suggesting rising export demand. However, U.S. imports have been increasing even faster than exports indicating that the U.S. is a net importer of pecans and is experiencing a growing demand for pecans. Per-capita consumption of pecans has remained relatively stationary, implying that the growth in total consumption of pecans has only been keeping pace with the growth in population.

4. The majority of growth in Texas pecan sales has been from improved pecans, which have experienced an average increase of over 53% from the 1970s to the 2000-2006. Texas sales of native pecans have declined approximately 36% over the same period of time. The change in demand from native to improved pecans began around 1977.

5. Producers of improved pecans always harvest their crop each year in order to recoup as much of their sunk costs as possible. Producers of native pecans, on the other hand, may not harvest their crop during low production years because their major expenses are associated with the actual harvest. Therefore, sales of native pecans are determined by availability more so than the sales of improved varieties.

6. An estimated 44% of the available assessment funds are collected and submitted to the Texas Pecan Board on average which effectively limits the potential impacts of the Texas Pecan Checkoff program.

7. Texas Pecan Board assessment revenues have been on a decline since the inception of the program in 1998 while promotion expenditures have been on the rise. Pecan promotion expenditures categorized as media expenditures represent over 69% of total expenses by the Texas Pecan Board on average.

8. The Texas Pecan Board has focused its advertising efforts on appealing to household consumption of pecans through advertisements including a radio campaign, the annual Pecan Festival, the annual State Fair, magazine articles, and recipe brochures. Because households typically consume improved varieties, Texas Pecan Board promotion may have impacted sales of improved varieties more than native varieties.
9. Major factors likely affecting the demand for Texas pecans include the prices of pecans, almonds, and walnuts; disposable income, variations in availability, the transition from native varieties to improved varieties over time, and Texas Pecan board promotion expenditures.

Specifications of the Conceptual Models

The second research objective was achieved in Chapter III and Chapter IV. Chapter III presented the foundational work for the second objective with the development of conceptual models to test the effectiveness of the Texas Pecan Checkoff Program in shifting demand for Texas pecans and the differential effects of Texas Pecan Board promotion on sales of improved versus native pecan varieties. A discussion on statistical and econometric techniques necessary to accomplish the objectives was presented first, followed by the defining of the conceptual models based upon the background and findings from Chapter I and Chapter II. A discussion of the econometric techniques that would be employed were then provided, including the ordinary least squares (OLS) estimator, the seemingly unrelated regression (SUR) estimator, the use of the lags for promotion and the dependent variables, binary variables, and hypothesis testing. In accordance with the necessary econometric techniques, the variables chosen for the conceptual models were discussed and defined based on the qualitative analysis presented in Chapter II.

Results from the Empirical Analysis

Chapter IV provided the results from the empirical estimation of the Texas pecan demand model defined in Chapter III. Chapter IV first addressed the estimation of an all pecans demand equation that measured the effectiveness of pecan promotion in shifting demand for Texas pecans. Secondly, Chapter IV addressed the estimation of the separate improved and native pecan varieties demand equations. Issues related to the determination of the proper demand equation for the all pecans demand equation were discussed first including the use of the log-log transformation in order to convert the estimated coefficients into elasticities. Next, the significant variables and the modified equation were discussed, and the appropriate lag length for the promotion variable was determined using the Akaike Information Criterion. The empirical results from the estimation of the all pecans demand equation were then presented. These results suggested that serial correlation existed and may have been inducing bias into the estimated parameters suggesting that the expected value of the estimated parameters are not equal to the true value of those parameters. An error correction model (ECM) was then considered, and the parameters were re-estimated. The results from the ECM estimation indicated that Texas Pecan Board promotion has had a positive impact on sales of all pecans.

Chapter IV proceeded by presenting the two separate demand equations for improved and native pecans. Following the conceptual models defined in Chapter III, the separate demand equations and the independent variables were presented. The study then addressed the issues related to the estimation of the two separate demand equations for improved and native pecan varieties. Specifically, the theoretical similarity between the improved and native pecan demand equations suggests that the seemingly unrelated regression may be most appropriate for estimating the model parameters due to potential cross-equation error correlation which may result in less efficient estimates. A cross model correlation and covariance matrix was then presented implying a high cross-equation error correlation. Estimation of the parameters of the demand equations indicated that Texas Pecan Board promotion expenditures have had a positive, statistically significant impact on sales of improved pecan varieties but no statistically significant effect on sales of native pecan varieties.

The third and fourth objectives were achieved in Chapter IV using the calculated promotion elasticity of demand to compute additional revenues and sales of pecans generated from the Texas Pecan Checkoff Program and then computing a revenue BCR (PBCR), net revenue BCR (BCR), a discounted net revenue BCR (DBCR), and a sales benefit-cost ratio (SBCR). The analysis first addressed the necessity for calculating a BCR in order to determine if the generated revenues outweighed the cost of the promotion program. Next, the study presented the methods for calculating additional sales, additional revenues, the benefit-cost ratio, and the sales benefit-cost ratio. Finally, the study presented and discussed the calculated statistics and their implications for the Texas Pecan Checkoff Program.

The empirical results from the OLS, SUR, and benefit-cost analyses suggested that promotion has had a significant impact on the demand for pecans. The specific conclusions of this research following the analysis include:

1. The OLS estimates of the demand for all pecans suggest that Texas Pecan Board promotion has had a significant impact on increasing the demand for Texas pecans.

2. Disaggregating demand into separate improved and native demand equations and estimating with the seemingly unrelated regression (SUR) indicate that Texas Pecan Board promotion has had a statistically significant positive impact on sales of improved pecans and no statistically significant impact on native pecans. This follows the hypothesis put forward in Chapter II regarding the Board's promotion focus on household consumption and its relationship with improved varieties.

3. The estimated promotion elasticity of demand for improved pecans is 0.0442, indicating that a doubling the promotion expenditures would lead to an approximately 4.2% increase in sales of Texas improved pecans.

4. The Texas Pecan Checkoff Program has generated an additional 21.5 million pounds of total sales of Texas improved pecans over the years 1999-2006. In terms of revenues, the program has generated an estimated $29.4 million in total additional revenues over the same time period.

5. The net revenue benefit-cost ratio for the Texas Pecan Checkoff Program from the years 1999-2006 is 40.7, suggesting that for every dollar spent on promotion approximately $40.7 dollars are generated in additional industry revenues. The sales BCR for the Texas Pecan Checkoff Program is 30.5 for the years 1999-2006, indicating that approximately 30.5 pounds of additional sales of improved pecans are generated for every dollar spent on promotion. A revenue BCR of 41.7 and a discounted BCR of 35.4 were also calculated.

6. The short-run and long-run own-price elasticities of demand for improved pecan varieties were calculated as -0.3231 and -0.3363. The elasticity of adjustment was calculated as 0.607, suggesting that demand only adjusts approximately 60% of the distance toward equilibrium demand.

Limitations of the Study

The research presented in this thesis incurred its share of problems, particularly with respect to data. Retail sales and price data were not available. Instead, grower-level sales and price data provided by the USDA were used. Utilized production was used in the computation of yield as a proxy for availability. This calculation would have been more accurate had total production been available. Another data limitation was the lack of monthly price, production, and sales data. The Texas Pecan Growers Association provided monthly promotion expenditure data for the Texas Pecan Board that could have been more precisely analyzed had the rest of the data been monthly. As with any study, an increase in time and available number of observations would have allowed tests of more hypotheses and other analyses that will be mentioned in suggestions for further research. Another limitation is that the benefit-cost ratios and elasticities calculated are point estimates. A way to provide more confidence with these predictions would be to calculate a range of values using confidence intervals.

Suggestions for Further Research

This study provides the first evaluation of the Texas Pecan Checkoff Program including a qualitative and empirical analysis of the demand for Texas pecans. Nevertheless, because this study is a pioneering effort, there is a broad field of opportunity for expansion upon this topic as suggested by the limitations of the study.

The computation of confidence intervals for all the parameters in this study would provide a more complete analysis. In particular, the calculation of confidence intervals for the benefit-cost ratio (BCR), sales benefit-cost ratio (SBCR), and promotion elasticity of demand would provide a range of values rather than a point estimate of the particular statistic. One common way of calculating confidence intervals is by using Student's t-distribution and the standard error of the estimated parameter. However, because the BCR and SBCR involve the product of two normally distributed variables (quantity sold and the elasticity) and the distribution of the product of two normal distributions is unknown, Fieller's theorem must be utilized by estimating both the variance of pecan sales and the variance of the promotion effects on sales of Texas pecans as well as the covariance between the two (Miller, Capps, and Wells 1984).

Second, specifying a supply equation would allow the results to be simulated with a supply response rather than holding supply perfectly elastic. This would produce results that reflect the dynamic relationship between supply and demand and how the effects on sales of pecans are determined by this dynamic relationship.

Finally, the collection of a more comprehensive set of data by USDA would allow a much more thorough analysis of the pecan industry. Specifically, the limitations on available bearing acreage, production, retail sales, and retail price data severely constrain research possibilities. The availability of this data would prove to be beneficial in analyzing the entire pecan industry and comparing the effects of promotion at grower and retail levels.

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VITA

Name:	Eli Del Moore
Address:	Department of Agricultural Economics Texas A&M University c/o Dr. Gary W. Williams College Station, TX 77845
Email Address:	elidmoore@gmail.com
Education:	B.S., Economics, West Texas A&M University, 2006 M.S., Agricultural Economics, Texas A&M University, 2008